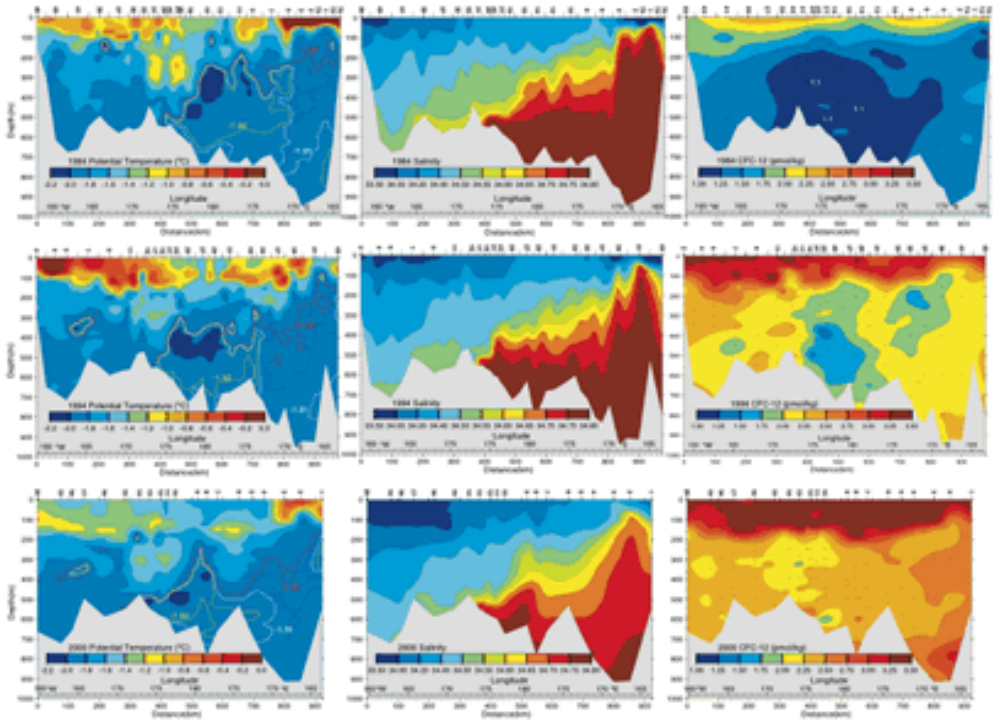

JOINT INSTITUTE FOR MARINE OBSERVATIONS

ANNUAL REPORT

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SCRIPPS INSTITUTION OF OCEANOGRAPHY

UCSD

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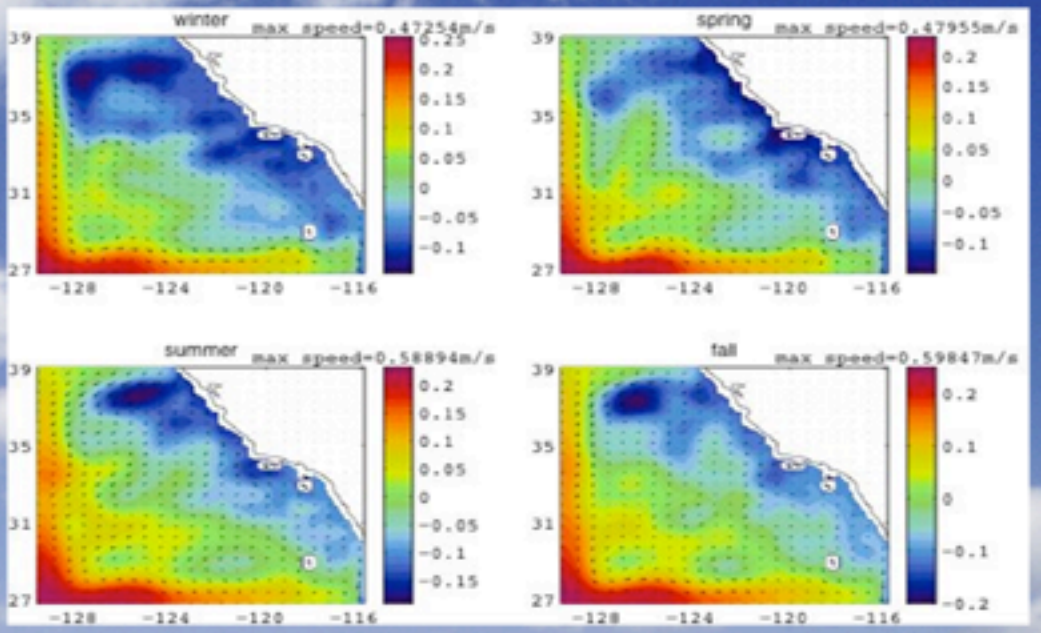
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INTRODUCTION

JIMO research activities of the third year (2003-2004) of the National Oceanic and Atmospheric Administration (NOAA) grant NA17RJ1231 are reviewed in this report. Included are reports from activities of all of the individual and coordinated research projects at the Scripps Institution of Oceanography (SIO) and other University of California (UC) campuses, as well as the CORC/ARCHES program for Lamont–Doherty Earth Observatory of Columbia University (LDEO) that received NOAA funding.

The purpose of JIMO is to provide a framework for enhanced cooperation and collaboration between the SIO and NOAA in oceanic and atmospheric research. Established in 1991, JIMO is one of thirteen OAR Joint Institutes within NOAA and is located on the SIO campus of the University of California at San Diego. Comprised of a talented, multidisciplinary scientific and administrative staff, JIMO's experienced leadership is represented by Dr. Peter Niiler, JIMO Director.

JIMO principally serves as a resource to bring together the research and infrastructure resources of SIO and NOAA. It also enhances the educational opportunities and breadth of training for students and post-doctoral fellows through close collaboration with the NOAA researchers and by team teaching by SIO, UC Davis, UC Santa Cruz and NOAA scientists at the National Marine Fisheries laboratories. Through these means the next generation of researchers will be trained to understand the special needs of NOAA's mission oriented and operational research methodology.

The specific recognition of the NOAA project support and research collaborators within NOAA are discussed in detail in the reports that follow. During 2003-2004, the NOAA research entities listed below were engaged with SIO in marine, atmospheric, climate, disaster relief and data collection collaborative activities with JIMO:

- Office of Global Programs (OGP)
- Atlantic Oceanographic and Meteorological Laboratory (AOML)
- Pacific Marine Environmental Laboratory (PMEL)
- National Center for Environmental Prediction (NCEP)
- National Weather Service (NWS)
- Climate Data Center (CDC)
- Western Regional Climate Center (WRCC)
- Climate Prediction Center (CPC)
- Southwest Fisheries Science Center (SWSFC/NMFS)
- National Center for Data Collection (NCDC)
- National Marine Fisheries Service (NMFS)
- Pacific Disaster Center (PDC)
- National Weather Service, Alaska Region (NWS)
- National Environmental Satellite Data Service (NESDS)
- Environmental Technology Laboratory (ETL)
- Climate Monitoring and Data Laboratory (CMDL)
- US Antarctic Marine Living Resources (AMLR)
- Forecast Systems Laboratory (FSL)
- Pacific Fisheries Environmental Laboratory (PFEL)
- Climate Diagnostics Center (CDC-CIRES)

RESEARCH HIGHLIGHTS

The research activities of JIMO are summarized by the following themes:

A. Climate and Coastal Observations, Analysis and Prediction Research
B. Biological Systems Research
C. Research in Extreme Environments
D. R & D on Observation Systems

Research highlights of the most recent individual research proposals are summarized in the Tables below and are more fully developed in the body of this report:

A. Climate and Coastal Observations, Analysis and Prediction Research

Consortium on the Ocean's Role in Climate [Russ Davis, SIO]	○ Time series of broad-scale upper ocean temperature and salinity, air-sea fluxes, and surface currents maintained. ○ Modern and historical, *in situ* and remotely sensed measurements, analyzed to describe key processes of oceanic climate change. ○ Adjoint data-assimilating model of the tropical Pacific is operating and is being optimized. ○ Underway CTD and Spray glider developments reach the stage of producing scientifically useful data.
Consortium on the Ocean's Role in Climate - Abrupt Climate CHange Studies (ARCHES) [Peter Niiler, SIO]	○ Demonstrated that pale oceanographic records from the Southern Ocean used for more than a decade to infer climate-related changes in ocean circulation are likely artifacts of changes in biological productivity. ○ Biases in radiocarbon ages on shell material from deep-sea cores have been identified. ○ The radiocarbon age of LGM water at 2000 meters depth in the Pacific (1500±200 years) is similar to todays. ○ Retreat from last glacial maximum (LGM) moraines on the east side of New Zealand's Southern Alps dated to 21,000 ^{14}C yr B.P. The advance to this position is dated to 22,500 ^{14}C yr B.P. ○ Strong seasonality changes involved in the abrupt climate changes of the Northern Hemisphere. Winter is dominant in these switches. ○ Sediment flux in the tropical Atlantic indicates strong focussing of sediment that may be related to the position of the ITCZ ○ The pattern of provenance variation in the Atlantic Ocean

	is a function of variation of continental inputs and their transport in currents ○ Proposed mechanism for decadel shifts in tropical Pacific climate and performed experimental predictability for the next 20 years. ○ Determined mechanisms linking decadal changes of tropical climate to persistent droughts and pluvials over North America. ○ Determined mechanisms whereby climate changes (temperature and precipitation) can have hemispheric and zonal symmetry ○ Determined links between ocean heat transport and mean temperature of plant and examined mechanisms governing how atmosphere and ocean heat transports can change
The Argo Project: Global Ocean Observations for Understanding and Prediction of Climate Variability (A coordinated project) [Dean Roemmich, SIO]	○ A collaborative (SIO, UW, New Zealand) series of voyages on *R/V Kaharoa* is now deploying floats throughout the South Pacific for coverage of the most remote region of the global ocean. ○ The first ARGO Science Workshop (Tokyo, November 2003) attracted 220 attendees, with poster sessions and oral presentations demonstrating a wide variety of research applications of ARGO data.
Economic Benefits of Weather and Climate Forecasts to California Energy Production Management [T. Barnett, SIO]	○ Identified the types of energy problems and decisions that could benefit from forecast information, including operational scheduling, electrical load forecasting, natural gas purchase planning decisions, and hydropower operational strategies. ○ Generated and communicated this information to energy partners, including the California Energy Commission, California Independent Systems Operator, San Diego Gas and Electric, and PacifiCorp. ○ Integrated forecasts into operational models and other decision processes, for example with “delta breeze” forecasting for CalSO and “tariff day” scheduling with SDG&E. ○ Evaluated the net economic benefit of forecast information; the total benefit of just the few projects we were able to address in the first year is conservatively estimated in the range of $5-$20M/yr. Note that this valuation is given by the stakeholders themselves of the value of this information.
Maintain the Time-Series of the California Cooperative Oceanic Fisheries Investigations [Elizabeth Venrick, SIO]	○ Equatorial El Nino short-lived along the west coast and had little impact upon the marine ecosystem. ○ Anomalous intrusion of Sub arctic water observed from the Gulf of Alaska to the Southern California Bight. ○ Biological observations continue to support the hypothesis of a “regime shift” occurring in 1999.
Global Drifter Program (A coordinated project) [Peter Niiler, SIO]	○ Reduced drifter construction costs by 23% since 2002. ○ Developed methodology of air-deployment of drifters into hurricanes. ○ Coordinated the deployment of additional 200 SVP drifters into the GDP array. ○ Increased the GDP array size from 600 (in 2000) to 1060 (in 2004).

California Applications Program (*A coordinated project)* [Dan Cayan, SIO]	○ CAP efforts are buoyed by the creation of the California Climate Change Center, managed from SIO (funded by the California Energy Commission) ○ CAP representation through scientific presentations at 8 conferences and 4 workshops ○ Publications and presentations illustrating the advance of spring across the western United States. ○ Increased awareness of expected temperature warming and unknown precipitation change for the future of California. ○ Fieldwork across California high-elevation and coastal transects progresses. ○ Publication of Accelerated Climate Prediction Initiative (ACPI) results. ○ Initiation of California Applications Program/California Climate Change Center report series. ○ Development of Santa Ana index for study of climate and autumnal wildfire risk. ○ Determined sources of variability of evapotranspiration in California ○ Examination of 'pineapple express' storms across the west coast of North America.
Scripps Experimental Climate Prediction Center (A coordinated project) [John Roads, SIO]	○ Routine daily to seasonal atmosphere and ocean forecasts furnished to IRI, NCEP. ○ Routine daily to seasonal fire danger forecasts furnished to USFS, CEFA, GFMC ○ Extensive forecast/analysis products provided to international CEOP model archives. ○ Global and regional coupled land, atmosphere, ocean model development and evaluations.
Dynamical Forecasting of ENSO: A Contribution to the IRI Network [Peter Niiler, SIO]	○ ENSO predictability was studied based on unprecedented retrospective forecast experiment covering the past one and a half centuries; in April 2004 this work was published in Nature and reported by press agencies all over the world. ○ Contributions of observational error in initial conditions, of random atmospheric variability, and of model biases into the prediction error of Zebiak-Cane model were investigated ○ Impacts of the small-scale ocean variability into the error in the initial ocean states obtained via data assimilation procedures were analyzed.
North Pacific Climate Variability and Steller Sea Lion Ecology: A Retrospective and Modeling Analysis [Art Miller and Bruce Cornuelle, SIO]	○ Evidence was seen for a climate-based mechanism in the decline of SSL in the GOA post 1976-77 regime shift. ○ A distinct change in the ocean circulation of the Gulf of Alaska after the 1976-77 climate shift occurred leading to increased eddy variance in the western GOA with unchanged eddy flows in the eastern GOA.
NCEP Ensemble Seasonal Forecast Verification and Application Project: A Contribution to the ARCS/IRI Network [John Roads, SIO]	○ ECPC ensemble forecasts now available to IRI/NCEP as part of their multi-model ensemble. ○ Long-range tropical predictability influenced by initial conditions as well as boundary conditions. ○ Seasonal forecast skill related to tropical SST variance.

Project Asian Brown Cloud (ABC): Regional Aerosol-Chemistry-Climate Observatories for the Indo-Asia-Pacific Region [Veerabhadran Ramanathan, SIO]	○ Investigation of long and short wave radiative forcing by mineral dust and soot over the Northern Indian Ocean during summer monsoon. ○ Simulation of radiometric observations and calculation of aerosol forcing at the ABC surface stations in Katmandu and Nagarkot, Nepal, ○ Coupling clear-sky aerosol radiative forcing calculations to satellite cloud information using International Satellite Cloud Climatology Project (ISCCP) data. ○ First time ever aerosol forcings observed in the Himalayan foothills to reveal substantial solar radiation blocking/absorption by atmospheric pollution. ○ Developed a regional scale 3-d model for use in forecast and hind cast analysis of 4-dimensional aerosol composition and size. Beginning to produce monthly 4-dimensional aerosol composition and size. ○ Successfully negotiated and executed a Memorandum of Understanding with the government of the Maldives and with United Nations Environment Program (UNEP)-Asia Pacific and the government of Nepal, the International Center for Mountain Development (ICIMOD) and UNEP for design, construction and operation of climate observatories. ○ Negotiation is underway with Thailand's Chulalongkorn University; while agreement to collaborate has been reached with University of Dhaka, Bangladesh and Indian Institute of Technology, Kanpur, India.
Forecasting Climate Changes over North America from Predictions of Ocean Mixed Layer Anomalies in the Tropical and Mid-Latitude Pacific [Nicholas Schneider, SIO]	○ The two-tier prediction system is used for long-lead climate prediction over some regions of North America. Mid-latitude forcing explains most variances in these regions during the years with normal tropical Pacific SSTs. ○ PDO, the leading mode of variability of sea surface temperature in the North Pacific is reconstructed to a high degree of accuracy from its own history, and indices of El Nino, of intrinsic variability of the Aleutian Low, and of ocean gyre anomalies in the Kuroshio Extension. ○ At low frequencies, the PDO contains ocean processes that have, at best, only a very small impact on the atmosphere. It might therefore be misleading to relate the PDO and climate anomalies at decadal time scales. Rather, ENSO and changes of the Aleutian Low should be used in the classification.
US Global Water and Energy Budget Studies: A Contribution to CEOP [John Roads, SIO]	○ Contribution of ECPC forecasts/analyses to CEOP model archive ○ Analysis of the global model's precipitation diurnal cycle shows a number of features similar to the observations ○ Further analysis of the hydrologic cycle shows the contribution of various hydrologic processes to this cycle. ○ Further work will focus on the corresponding diurnal variations in the atmosphere and surface energy cycles.
Evolution of ENSO and Tropical Climate Pacific [Christopher Charles, SIO]	○ Comprehensive, high fidelity time series of ENSO being developed, covering episodes of different global climate conditions ○ High precision estimates of mean temperature of the

	tropical ocean over the last 1100 years ○ Collection and dating of fossil coral specimens that constitute an unparalleled archive of variability in the tropical Pacific ocean
Global Model Investigation of Warm Season Precipitation for North American Monsoon Experiment [Guang J. Zhang, SIO]	○ Performed multi-year simulations of the North American Monsoon using NCAR GCM. ○ Significantly improved the diurnal cycle of convection over the North American continent in the NCAR GCM. Published one journal paper based on the analysis. ○ Participated in the inter-model comparison project with the GFDL and NASA models.
IRI/ARCS Regional Modeling Applications Project [John Roads, SIO]	○ New Land Surface Parameterizations added to RSM. ○ Precipitation Assimilation added as regional downscaling tool. ○ Experimental RSM Fire danger forecasts evaluated.
Impact of Climate Variability on Eastern North Pacific Sea Levels [Peter Bromirski, Arthur Miller and Reinhard Flick SIO]	○ Nine data sets of greater than 65 years duration were obtained; a 20-year gap in the Ketchikan, AK data set was digitized from microfiche to provide the fourth longest, nearly continuous, hourly tide gauge record along the U.S. West coast. These long hourly time series are suitable for studying interdecadal SLH variability along the U.S. West Coast. ○ EOF analysis of meteorologically-corrected tide gauge monthly anomalies shows a distinct north-south pattern for the second mode, with a change in sign of the EOFs between San Francisco and Crescent City, CA, similar to results presented in Chelton and Davis (1982) who used time series less than half as long. ○ PC1 levels during the 1982-83 and 1997-98 El Nino winters were more than a factor of two greater than average winters, indicative of much greater forcing over the North Pacific during those periods.
Summertime Atmospheric Hydrologic Cycles [John Roads, SIO]	○ Comprehensive study of the US hydrologic study. ○ Comprehensive studies of the Southwest Hydrologic Cycle.
CLIMAS – CAP Partnership Activities [Anthony Westerling, SIO]	○ Climate information is widely used by fire managers, but there is potential for greater and more effective use of available information. ○ This study could be readily extended to other land management agencies, and to State and local fire agencies. ○ In some cases the science is available to integrate climate information into decision-making, but organizational changes may be required to fully realize the value and increased efficiency of climate forecasts and information. ○ In other cases, forecast accuracy will have to be increased before fire managers will be willing to integrate climate forecasts into their management strategies.
Preparation and Analysis of an Extensive Historic Dataset of Ocean Carbon Dioxide Partial Pressure and Related Measurements [Charles Keeling, SIO]	○ Performed calculations of pCO2 from shore-based measurements of dissolved inorganic carbon

Potential Application of Recent Collaborative Research Results to Operational Activities at the National Weather Service, Alaska Region [James Simpson, SIO]	○ First high spatial resolution (1 km), long-term mean monthly climate analyses of Alaskan surface temperature and precipitation ○ Developed and validated end-to-end, satellite-based, high spatial resolution (1 km) and high temporal resolution (1 hr) retrievals of aerial extent of snow cover and insolation. Use of these new tools in hydrologic basin models reduced the RMS error in modeled stream flow by 15 to 20% for the Sierra Nevada basins studied when compared against 1 minute *in situ* stream flow data supplied by U.S. Geological Survey.
Travel Support for International RSM Workshop [John Roads, SIO]	○ Workshop held to phase out older version of RSM97 to newer G-RSM CVS, which is the only supported option by the Scripps Experimental Climate Prediction Center. ○ Previous identified problem of too much precipitation over mountaintops solved by the new pressure diffusion parameterization.
SIO's Participation in US GODAE: Sustained Global Ocean State Estimation for Scientific and Practical Application [Dean Roemmich, SIO]	○ Provide a direct linkage between the assimilation elements of the ECCO GODAE consortium and the Argo float project and other in situ ocean observational elements. ○ Provide the required knowledge of datasets and expertise with instrumentation.

B. Biological Systems Research

Cooperative Studies of Pacific Coast Salmon: NOAA Fisheries and the University of California, Santa Cruz [Pete Adams, UCSC]	○ Conducted seven field studies addressing population dynamics, life-history patterns, genetic structure, and sampling methods for anadromous salmonids. ○ Led NOAA Fisheries Technical Recovery Teams charged with developing scientific criteria to serve as a basis for ESA-listed salmonid species recovery plans. ○ Initiated the development of a Comprehensive Statewide Coastal Salmonid Monitoring Plan with California Department of Fish and Game (see www.calmonitor.org). ○ Provided GIS (Geographical Information System) support for the technical recovery planning process of ESA-listed Salmonid species and for research-monitoring efforts. GIS products were used to identify independent populations, potentially suitable habitat, and connectivity among populations. ○ Completed a documented list of streams within the Central California Coast Evolutionarily Significant Unit known or suspected of historically supporting Coho salmon, and associated recent survey information, enabling analysis of trends in occupancy rates within the ESU. ○ Completed basin-wide stratified survey of the lower Klamath River to examine population structure of anadromous and non-anadromous *O. mykiss* using micro chemical, genetic, and meristic traits. ○ Estimated rates at which *O. mykiss* from 9 northern California rivers and hatcheries adopted either an anadromous or non-anadromous life history form in relation to the maternal form to better understand links between these population segments. ○ Developed a statistical model to estimate stream

	residence time of spawning Coho salmon for improved escapement estimates using "area under the curve" methods, and evaluated the model using field data.
The Center for Stock Assessment Research (CSTAR) [Marc Mangel, UCSC]	○ Subsetting methods receiving great interest as a means for dealing with recreational data ○ Bayesian nonparametric stock assessment methods to be applied to ICES data in June, 2004 ○ Successful completion of the first ever stock assessment for California sheephead. ○ Three post-docs find excellent positions and former CSTAR student Teresa Ish founds Sustainable Fishery Advocates.
A Joint Program for Training and Research in Marine Resource Management Modeling [James Wilen, Louis Botsford and Alan Hastings, UCD]	○ Developed integrated bioeconomic spatial/dynamic model of the sea urchin fishery. ○ Investigated conceptual models of reserves sitting under different dispersal assumptions. ○ Developed method for estimating a population's lifetime egg production parameters. ○ Estimated new models of fishermen behavior in order to understand spatial distribution of effort.
Dynamics and Mechanisms of HAB Dinoflagellate Mortality by Algicidal Bacteria [Peter Franks and Farooq Azam, SIO]	○ Isolation of a bacterial strain able to cause loss of motility and ecdysis in Lingulodinium polyedrum. ○ Algistatic effect of the bacterium is density dependent, as hypothesized. ○ Preliminary evidence suggests that proteases play a role in ecdysis induction and algistasis ○ Molecular technique (TSA-FISH) optimized to locate bacteria attached to dinoflagellate.
Studies in Groundfish Habitat [Pete Adams, UCSC]	○ Conducted 53 research cruises ○ Sampled more than 25,000 groundfish from 61 species ○ Tagged 585 fish ○ Developed age determination criteria for two species (green spotted rockfish and sand sole) ○ Developed a fecundity estimate for green spotted rockfish
Shipboard Studies of the California Current System off Central California [Baldo Marinovic (UCSC), Francisco Chavez (MBRI) and Curtis Collins (NPS)	○ Development and installation of an underway pCO2 monitoring system during all quarterly CalCOFI cruises. ○ Integration of Central California Datasets with comparable Southern California Datasets.
Climate-Driven Bottom-Up Processes and Killer Whale Abundance as Factors in Stellar Sea Lion Population Trends in the Aleutian Islands [George Hunt, UCI]	○ Flow of the Alaska Coastal Current goes as far west as Samalga Pass, several 100s of km farther west than formally believed. ○ Samalga Pass marks the boundary between a primarily neritic ecosystem to the east and an oceanic ecosystem to the west. ○ Marine bird species composition and food use changes at Samalga Pass. ○ Evidence that Samalga Pass is an important ecolocical boundary and that conditions east and west of the pass are very different

Ocean and Estuarine and Ocean Physiological Ecology of Salmon [Susan Sogard and Gary Griggs, UCSC}	○ Little or no growth for juvenile Chinook salmon while in San Francisco Estuary; rapid growth once in marine environment. ○ Juvenile Chinook salmon in the Gulf of the Farallones grew better and stored more lipid during the 1998 El NiZo than the 1999 La NiZa. ○ In the ocean, Chinook salmon from different natal streams in the Central Valley mix together; stocks from natal sources do not segregate by origin or ocean location. ○ Growth of steelhead during estuarine residence varies 4-fold among different estuaries and between upstream freshwater habitats and the estuary. ○ In Scott Creek watershed, which contains a small conservation-like hatchery, little or no interaction between natural and hatchery steelhead or Coho salmon during emigration to sea; hatchery fish did not remain in system and went to sea soon after release. ○ Juvenile steelhead and Coho salmon are seawater-ready during April-June; lose readiness (desmoltification) during summer and fall while in estuary. ○ Juvenile steelhead tend to inhabit cooler temperatures within the extant range; however, when the temperature range moves to higher values, the cooler regions may be as warm, or warmer, than the warmest areas previously.
Early Life History Studies in Rockfish [Susan Sogard, UCSC]	○ Development of new trapping methods for early juvenile rockfishes. ○ Integration of physical and biological data in defining essential fish habitat.
Genetic Population Structure of Central California Coastal Salmonid Populations [Susan Sogard, UCSC]	○ Completion of genotype dataset for approximately 4000 Coho salmon, from the entire range of the species in California. ○ Provided genetic data to guide breeding matrix for the first year of a Coho salmon captive broodstock program in the Russian River. ○ Identified and optimized 18 micro satellite genes in coastal Chinook salmon for future analysis.
Right Whale Studies in the Gulf of Alaska and Bering Sea [John Hildebrand, SIO]	○ New information on the seasonality of right whales ○ Improved technique for acoustic data analysis.
Extension of Paired Oceanographic-Whale Call Sampling [John Hildebrand, SIO]	○ Two new high frequency acoustic recording packages deployed to study odontocetes. ○ Improved technique for acoustic data analysis.
Physical, Chemical and Phytoplankton Time-Series Database for the Antarctic Marine Living Resources (AMLR) Surveys, 1990-2002 [Osmund Holm-Hansen, SIO]	○ Collated 12 years of time-series data collected during the Antarctic Marine Living Resources (AMLR) program (1990-2002) into a single unified database. The concern of this project included only data related to phytoplankton dynamics and physical oceanography.
Phytoplankton Studies in Support of the U.S. Antarctic Marine Living Resources (AMLR) Program [Osmund Holm-Hansen, SIO]	○ 209 stations in the Elephant and Shetland Islands area of the Southern Ocean were sampled for phytoplankton stocks and optical characteristics of the water column. ○ In collaboration with our NSF-sponsored project and the Global Drifter Program, 40 Lagrangian drifter buoys were

	released in the study area to determine current flow patterns. ○ Low iron concentrations limit phytoplankton biomass in the low chlorophyll regimes of the AMLR sampling grid.

C. Research in Extreme Environments - No research funded.

D. R & D on Observation Systems

Joint Project Agreement Concerning CSRC System [Yehuda Bock]	○ Established vertical datum for 20 continuous GPS sites in southern California by leveling from NAVD88 benchmarks ○ Completed extensive height modernization surveys in the San Joaquin Valley. ○ Researched and drafted guidelines for establishment and maintenance of the California Spatial Reference System ○ Performed extensive outreach and education for the CSRC user community. ○ Published XML schema for GPS site metadata. ○ Published a new epoch date (2004.0) for coordinates and velocities for all CGPS stations in California.
Implementation of a Real-Time Precipitable Water Capability Using the Global Positioning System [Yehuda Bock]	○ Increased data processing session length from previous 24 hours to 48 hours (on a faster processor for the primary analysis) and 36 hours (on a slower processor for the redundant analysis). ○ Longer orbit arcs improved the accuracy of predicted segment of the precise orbits. ○ Introduced a satellite rejection scheme using satellite health status message in addition to orbit overlap checking scheme. ○ Replaced previously implemented failover system using switch over mode (backup processing starts only if primary processing fails) with one using redundant mode (two processing running simultaneously).

RESEARCH TASKS AND THEMES

RESEARCH TASKS

Under the Joint Institutes cooperative agreement five tasks are defined by NOAA which allow JIMO to group and account for research more easily. The tasks are identified as follows:

Task 1. Administration

Task 1.1 is for administration of the Institute and includes support for the JIMO Director's office and minimal support for the staff. It includes costs associated with annual scientific meetings that are deemed important for the JIMO Director to attend, workshops sponsored by JIMO, web-site development, funding for the Joint Institute Directors and administrative board meetings and formal reviews.

Task 1.2 is to support the post-doctoral fellows and provide a visiting fellows program. It is intended to be a very visible mission of this institute. We envision that each of the themes will support post-doctoral fellows and visiting fellows. They would be allowed the freedom to work with a variety of JIMO scientists on a rotational basis, crossing disciplines. Graduate student support, if appropriate, is provided in individual investigator proposals as funded. The visitors program may invite NOAA scientists to assist in teaching courses to graduate students.

Task 2. Joint NOAA Laboratory/JIMO Programs

The collaborative proposal has NOAA and Scripps working together jointly on research themes. These proposals are broken out by theme and include all research associated funding including the funding of salaries, benefits, as well as instrumentation and computer time.

Task 3. Individual Science Projects

A cooperative research proposal is one which is specific to the JIMO theme areas, but is submitted by individual scientists of JIMO. The distinction here is that there is a loosely bound tie between individuals working on similar themes or topics. It is also seen that this may be a mechanism for developing collaborative proposals in the future, as well as encouraging new areas of research to develop. These proposals are broken out by theme and include all research associated funding including the funding of salaries, benefits, as well as instrumentation and computer time.

Task 4. JIMO Cooperative Research Programs with Other Research Institutions

In support of NOAA's Mission and Strategic Plan, JIMO's Task II was developed to strengthen and coordinate our University of California's multi-campus environment by establishing a regional concept for marine and atmospheric sciences. Proposals would include research conducted at other University of California (UC) campuses, such as UC-Santa Cruz and UC-Santa Barbara, as well as other academic institutions, and non-profit research institutions, when appropriate, in support of JIMO and NOAA research missions, and in meeting NOAA's strategic goal of environmental stewardship. These proposals will include a program development cost (PDC) that will support the Visiting Fellow/Post Doctoral Fellows program at JIMO/SIO (Task 1.2).

Task 5. JIMO Research Infrastructure Proposals

Because proposals relevant to JIMO will be using a variety of observation platforms in order to carry out their research objectives, we have included an infrastructure task by theme area which includes proposals for platform and specialized research facilities. We anticipate that a number of other agencies will be partners in supporting the platform infrastructure.

RESEARCH THEMES

Four thematic areas form the basis for research performed in partnership with NOAA. Each of these areas are relevant to the NOAA mission elements, particularly those of environmental assessment and prediction and environmental stewardship.

(A) Climate and Coastal Observations, Analysis, and Prediction Research

The primary goals for this research theme are to understand the remote forcing functions that control fundamental ocean and atmosphere processes and to utilize this knowledge for prediction. For JIMO the basis of interest is primarily the Pacific, although other areas may be studied as a model or to put the Pacific information in context (e.g., Indian, Arctic). These thrust areas include the following:

Ocean observations will utilize many of the in-place observation systems such as the TAO/TRITON array, drifters, floats, and satellite remote sensing to provide information for models on climate prediction at the ENSO to decadal space and time scales. Defining the ocean's role in governing the climate necessitates the expansion of large-scale, long-term field observation and modeling efforts begun over the past few years in the Pacific to the global system. A networking of these programs in the University California to NOAA research projects is essential to the success of the effort. Deep ocean circulation constitutes another emphasis of this theme area that stresses the fundamental processes governing geochemical pathways. Deep ocean characterization, including deep-water formation and tracking that uses state-of-the-art floats, moorings, as well as unique observations and monitoring techniques, such as chemical or geochemical tracers for signature analysis. In addition, proxy data is used in providing the past climate variability.

Climate prediction and modeling is concerned with the development and evaluation of a wide range of climate models. Of interest are global atmospheric models, regional atmospheric models, global and basin ocean models, land surface models concerned with surface hydrology and fire danger. JIMO goal is to eventually develop coupled atmosphere, ocean and land models that provide greater predictability than is possible with current uncoupled models of these processes. Defining the limits of predictability for these systems requires extensive computational resources and collaborations with NOAA centers that are engaged in similar research efforts.

Coastal ocean assessment and forecasting seeks to measure and define the basic processes in the near shore ocean (eddies, upwelling, currents), and atmosphere (fog, inversions, UV). Research is required to characterize the feedbacks between the coastal ocean and atmosphere and to assess the historical variability. The ultimate goal is to be able to perform short term predictive modeling for such areas as natural hazards (oil spill), navigation and commercial recreation and the recruitment of pelagic stocks. Considerations must be given to mesoscale to small scale processes and temporal scales of hours to decadal. The 70-year, daily SIO pier data and shore stations measurements, in situ moorings, stationary platforms, as well as aircraft and other remote sensing observations will be used to generate the necessary scientific data.

Atmosphere and ocean/atmosphere exchange will continue and strengthen research of mutual interest to SIO and NOAA scientists. These studies include: "teleconnections" and other large-scale meteorological phenomena; air-sea physical and chemical exchange processes; and, global distributions and trends of climate-forcing due to anthropogenic and biogenic atmospheric trace gases and aerosols.

Biogeochemical cycles need to be further defined for their implications for global climate change. These include ocean, atmospheric and terrestrial components of the carbon cycle, oxygen cycle, UV chemistry, and trace metals among others. In addition, proxy data such as ice cores will be used to measure a wide array of paleo-climatologically important physical and chemical parameters such as the CO_2 content and isotopic composition of air recovered from bubbles trapped within the ice.

(B) Biological Systems Research

The population dynamics and physiological ecology of marine ecosystems is a complex research question, which involves finely tuned long-term observation programs. Process oriented research at the system and individual level lead to the fundamental understanding of the physiology and life cycle dynamics of important species. This theme area includes the following four thrust areas:

Fisheries research analyzes long term trends of ecosystems where fisheries are concentrated using data bases such as the four-decade-old CalCOFI program, examines the schooling and behavior of selected species, develops new methods of stock assessment, and forecasts and investigates the effects of fishing activities on the environment. Food chain dynamics is of particular interest in the success of larval populations. Basic studies on the physiology and behavior of such species as sharks are of particular interest. Paleo-oceanographic techniques for the reconstruction of past distributions and abundances are necessary to help decipher the natural variability of the selected commercially important species.

Marine ecosystem monitoring and forecasting examines the distribution and abundance of organisms at all levels of the food chain in relation to their environment, primarily the physical and chemical structure. Ocean currents as transport routes, episodic events as introduction mechanisms, migration routes and impact of climate change on species distributions is featured. Patchiness in the vertical as well as in the horizontal due to mesoscale and small-scale structure is a research topic.

Protected species dynamics focuses upon the refinement of acoustic sensing and tagging methods, the study of population dynamics, habitat utilization, foraging habitats, and diving physiology of marine mammals. In addition, the impact of anthropogenic sound on the migration routes and behavior of these mammals is a study area necessitated by the Marine Mammal Protection Act and the increase of anthropogenic activity such as shipping, drilling and general development of the near shore zone.

Protected areas and reef systems ecology seeks to do research aimed at protecting marine habitats from anthropogenic change. Reef habitats in particular may harbor clues to past changes in climate in their physical structure. These sensitive systems harbor a diverse community and can represent a historical record of past climate events. In many cases, these habitats are threatened and in need of mitigation.

(C) Research in Extreme Environments

A third theme area for the JIMO is centered on research in extreme environments. In all of the following cases, research necessarily includes the development or rugged sensors, platforms and data transmission devices to perform under adverse conditions. The "adverse conditions" range from ice to high pressure, high temperatures, fog, huricanes, sulfur pools and anoxia to name a few. The theme area is divided into four major thrusts:

Sea-floor processes emphasize the characterization of unexplored environments and subsequent process definition in these newly described habitats. Hydrothermal vent processes continue to be an area of interest for biologists, chemists and geologists. The physiology and physiological ecology of these organisms such as extremophiles and sulfur bacteria are of interest. Vent chemistry and heat transfers into abyssal waters are areas of potential study. Ridge processes and associated crustal dynamics constitute a significant fraction of the proposed research. Methods for the better characterization of these processes or for shelf topography of the seafloor are included.

High-latitude research defines the functional dynamics between Antarctic krill populations, their environment and their predators use bioacoustic and conventional technologies to acquire data for input into pelagic ecosystem models. UV radiation and ozone abundance monitoring and modeling and prediction of health effects will be a major research topic in this thrust area. Cycles and controls of ocean production in high latitudes extending into the southern ocean and characterization of seasonal circulation patterns in the Arctic and Antarctic are included in this topic area.

Strongly forced systems studies focuses on monsoonal dynamics and variability, hurricane prediction and observations and their tracking and modeling, and research in hazard impacted areas.

Toxic environment research takes place at the limits of biological survival. Anoxic waters, sulfur pools heavy metal contaminated sediments present difficult regions for measurement. Most of the extreme conditions are due to chemical or geochemical processes causing noxious conditions.

(D) R&D on Observation Systems

The fourth theme area for research is unique in its cross cutting nature. Observation system development ensures that there is state of the science research and development efforts brought to bear on the scientific problem. Platforms and instrumentation re-engineering, observing system reconfiguration, and data merging and display techniques modification takes place here. This is the engineering component of a smoothly operating research effort.

Extreme technology development focuses on rough weather deployable mooring, low detection optical/chemical sensors, high pressure/heat tolerant probes, optic/acoustic nets/pens for stock assessment, queryable communications, minimal/self tending arrays, non-fouling chemical sensors, aircraft deployable sensors/drifters/buoys. Improved ROVs and submersibles are among the technologies that need to be developed, refined or redesigned. Acquiring enabling technologies and platforms such as the potential addition of new SIO submersibles will significantly expand the research capabilities of the JIMO.

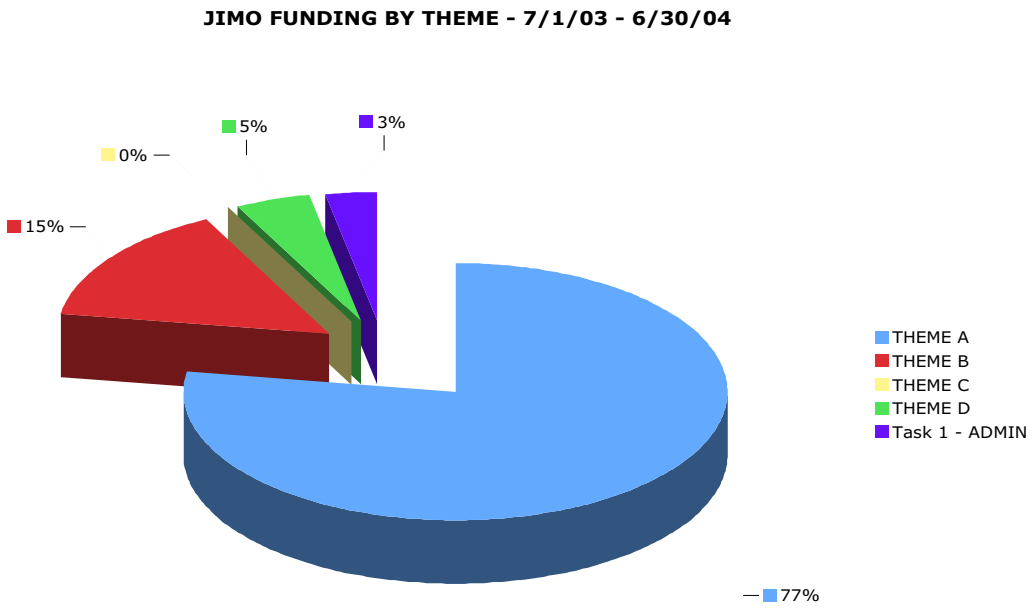
Systems engineering evaluation allows a probing look at the optimal design at the observation system as a system rather than a sum of the components. The goal is to evaluate the existing observing systems and optimize the system at all levels including sensor,

instrumentation, platform and sampling design and to reassess the systems architecture at various intervals. Such an ongoing in-depth look at observing systems will ensure the evolution of the systems as the state of the art of science develops.

Information systems management will be in close collaboration with the NOAA units that have direct responsibility for this function. Quality assurance and control of data as well as the dissemination of that data to scientific users is a critical function.

Systems modeling and simulation is an essential part of the information transfer of the research. Here the data is presented to give the most information to the potential user. The scientific models may be coupled with socio-economic or development models for use in policy making. The appropriate simulation and animation techniques can also help in the dissemination of the data for educational purposes to the public or K-12 level.

JIMO EMPLOYEE AND DISTRIBUTION OF FUNDING SUMMARY



FY '03 EMPLOYEE SUMMARY

Title	Number of Employee's
Research Scientist	1
Project Scientist	3
Visiting Researcher	1
Affiliated Researchers	3
Post Graduate Researcher	2
Staff Research Associate	5
Programmer Analyst	3
Business Officer	1
TOTAL	19


17
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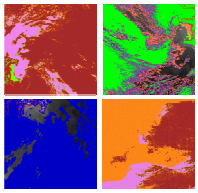


THEME A: CLIMATE AND COASTAL OBSERVATIONS, ANALYSIS, AND PREDICTION RESEARCH

THE CONSORTIUM ON THE OCEAN'S ROLE IN CLIMATE

Russ Davis (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The Consortium on the Ocean's Role in Climate (CORC) fosters research in ways to improve and expand our ability to observe seasonal-to-interannual climate variability. Work includes implementing pre-operational elements of the climate observing system, exploiting those observations to describe the ocean's role in climate, and developing new technologies and methods to improve climate observations and their interpretation, including data assimilating models. Observations are focused in the Pacific Ocean.

APPROACH/EVALUATION AND METHODOLOGY

Scientists from Woods Hole Oceanographic Institution (WHOI) and Scripps Institution of Oceanography (SIO) collaborate in the CORC projects:

- D. Roemmich (SIO) and R. Weller (WHOI) carried out high-resolution XBT/XCTD sections and broad-scale sampling of air-sea fluxes from voluntary observing ships;
- P. Niiler (SIO) collaborated with scientists at AOML to deploy CORC surface drifters, some with surface salinity sensors, and to analyze the results;
- B. Cornuelle (SIO) and D. Stammer (SIO) are perfecting the data-assimilating MITGCM model nested in ECCO-program global ocean assimilation to describe climate variability in the tropical Pacific Ocean;
- Miller (SIO) is developing a nutrient-plankton-detritus model to be imbedded in the assimilating MITGCM;
- R. Davis (SIO) is developing underwater glider capabilities with the intent of implementing sustained near-boundary observations to augment the Argo program;
- D. Cayan (SIO) uses weather observations and bulk formulas to construct fields of air-sea heat-flux components and to explore the relation of these fluxes to ocean surface temperature and heat content;
- D. Rudnick (SIO) is developing an underway CTD to expand the capability to monitor salinity; and
- R, Scmitt (WHOI) is improving the performance of salinity measurements from profiling Argo floats using laboratory characterizations of behavior and field tests.

RESEARCH ACCOMPLISHMENTS

Observations. Pre-operational elements of the Climate Observing System were maintained with all data distributed through national data systems: (1) 100 SVP drifters were deployed in the tropical Pacific; 40 were focused on Luzon Strait; others with CTDs were deployed in the East China Sea to extend a 5 year series of Yangtze River outflow and to establish the capability for long-term surface salinity observations. (2) Quarterly high-resolution expendables (HRX) transects were occupied from New Zealand-to-Callao, Honolulu-to-Coronel, and Fremantle-to-Durban, including XBT profiles to 800 m at spatial intervals from 10 to 40 km to resolve boundary currents and interior eddies for calculating integrals of geostrophic transport; sparse XCTD profiles are used to observe large-scale variability of the T/S relation. (3) Continuous high-quality surface meteorological observations were maintained on three VOS's, two in the Pacific and one in the Atlantic, using Automatic IMET packages. (4) Floats from the Argo program were deployed from VOS's as requested and the new Sippican T-12 2000-m XBT's were tested on these vessels. (5) Nine

FSI-equipped profiling floats were deployed in the eastern tropical Pacific and performance is being monitored in this region where CTD dynamic response is an issue.

Science. Several descriptions of the ocean climate system were developed: (1) Analysis of short-wave heat fluxes computed from bulk formulas shows a 10 to 40 W m^{-2} bias between daytime and nighttime observations of cloud cover – this may indicate the difficulty of accurate visual cloud estimates at night. (2) HRX data have been incorporated in regional, basin-wide, and global analyses of oceanic heat storage using a new technique for combining XBT and satellite datasets. (3) Using HRX datasets, regional studies of circulation and heat budgets have been completed in the northeast Pacific the southwest Pacificand Drake Passage (4) Surface velocity was mapped in the vicinity of the Luzon Strait from both CORC and historical drifter observations, showing that surface particles enter the South China Sea through the Luzon Strait, south of 21ºN. Analysis of historical drifters in the Southern Ocean describe surface flow in the Agulhas extension and disclose seven semi-permanent meanders of this current as can be explained by the theory of eastward flowing jets.

Development. The year has seen significant progress on several projects to improve climate observations. The data-assimilation project is the most encompassing. The tropical version of the MITGCM is now routinely assimilating altimetry, surface temperature and climatological T & S profiles while imbedded in the global ECCO assimilating model. One-year tuning experiments show that tropical instabilities limit predictability and require use of artificially large damping during the backwards adjoint runs. ECCO assimilation appears to have improved raw forcing fields and the iterations of the nested model dramatically improves the fit to data. Assimilation will turn to in situ CORC data soon. Progress has also been made developing (within a version of ROMS) a biological sub-model for lower trophic levels (nutrients, phytoplankton) that will be ported to the MITGCM when it is understood and tuned.

The developmental Spray underwater glider (a slow 100 pound AUV that profiles vertically to move forward) and the Underway CTD (a 10 pound profiling probe deployed and recovered from underway ships) have seen their first serious use for science (vs. engineering tests) in joint studies with ONR. Five Sprays repeated offshore transects for five weeks in Monterey Bay, demonstrating reliable operation, constraining ocean forecasts models, and measuring scales of variability. The Underway UCTD measured 97 profiles at 10-km horizontal and 5-m vertical resolution while the ship steamed at 10-13 knots. The section clearly showed thermohaline variability on sound speed. The MicroCAT CTD sensor used on SVP drifters was shown to be stable to 0.02 psu for more than 300 days operation. In plunge tests through sharp T-S interfaces the dynamic response of the SBE CTD used on many Argo floats was determined and a correction algorithm is being developed.

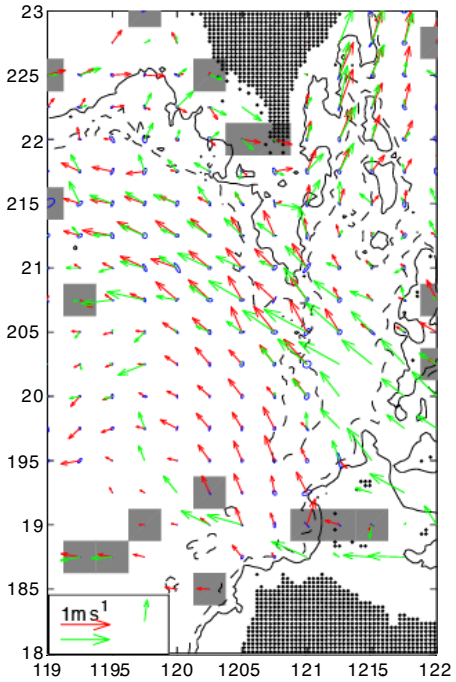


Figure 1. The SVP drifter seasonal time mean velocity from the period of October -.January in the vicinity of the Luzon Strait (green arrows are from historical data and red arrows from 2004 field deployments.

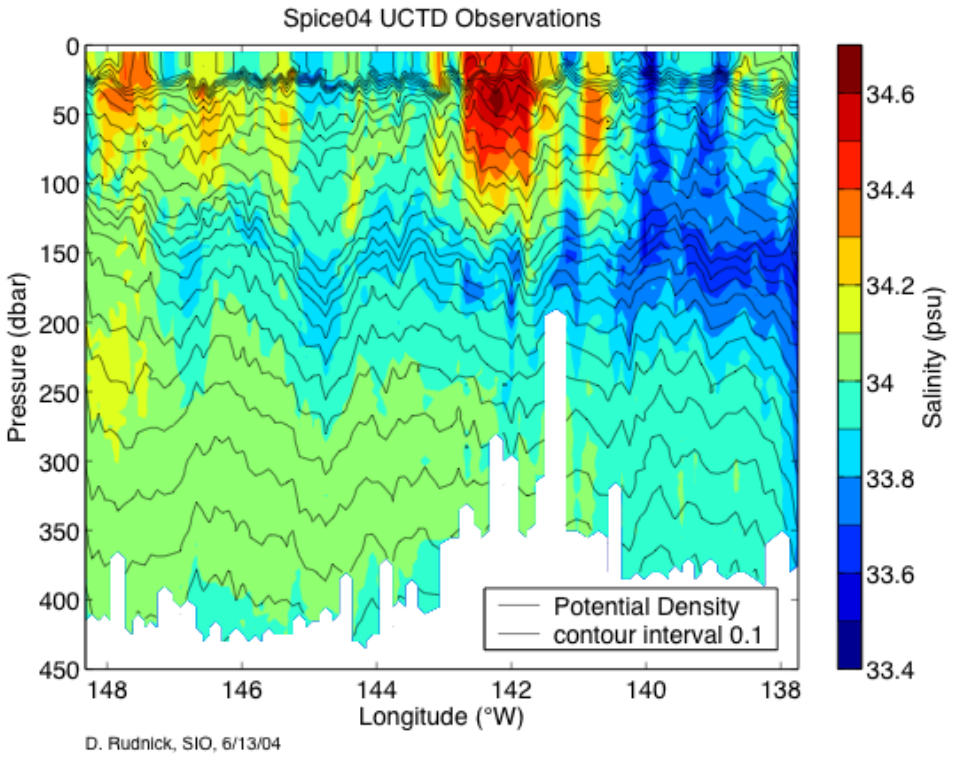


Figure 2 . A 1000-km Underway CTD section of salinity (color shading) and potential density (contour lines). The section had 10-km horizontal resolution. The changing depth of the profiles was directly related to ship speed. Over the western half the ship speed was 10 knots and casts were mostly deeperr than 400 m. The spring mixed-layer depth of 20 m is evident as is the 100-150 m depth of the remnant winter mixed layer. Salinity features can be seen covering the depth of the winter mixed layer.

CONSORTIUM ON THE OCEAN'S ROLE IN CLIMATE ABRUPT CLIMATE CHANGE STUDIES (ARCHES)

Peter Niiler (SIO)
Lamont-Doherty Earth Observatory at Columbia University

PALEO SEA ICE DISTRIBUTIONS

Robert Anderson and Lloyd Burckle (LDGO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Improve stratigraphic methods to provide age control for paleoclimate records extracted from Southern Ocean sediments, by developing novel radiocarbon dating methods and by developing new biostratigraphic methods; and

Develop high-resolution records of climate change in the Southern Ocean, extracting from marine sediments records of ice rafting, changes in ocean circulation, and biological responses to climate change.

APPROACH/EVALUATION AND METHODOLOGY

In collaboration with Anitra Ingalls, now at Univ. Washington, we have been developing a method to radiocarbon date the organic template inside of diatom opal frustules to provide a chronological framework in sediments that lack calcium carbonate, normally used for radiocarbon dating.

We have been comparing the relative abundance of Eucampia Antarctica (a diatom species) with independent indicators of climate variability in well-dated cores to assess the suitability of this species for biostratigraphy.

We have applied standard paleoceanographic techniques in collaboration with colleagues at Lamont and with Julian Sachs (Massachusetts Institute of Technology) to reconstruct past changes in ocean circulation, ocean biological productivity, and ice rafting in the Southern Ocean.

RESEARCH ACCOMPLISHMENTS

Our research involves several related subprojects:

Development of a novel technique for radiocarbon dating the opal-intrinsic organic matter in diatom shells has been put on hold this year as Anitra Ingalls moved from her post doc position at Harvard University to a faculty position at the University of Washington.

Our biostratigraphic work with Eucampia antarctica this year is about a month away from reaching its next milestone. Work is going well, but it is premature to describe any new findings here.

We are using multiple proxy records from the Cape Basin (South Atlantic Ocean) to argue that past (published) reconstructions of climate-related changes in ocean circulation based on the carbon isotope composition of benthic foraminifera from this region have been compromised by ecological artifacts. These artifacts are inferred to be linked to enhanced biological productivity of this region, due in part to iron fertilization by lithogenic material derived from South America. The strontium isotopic composition of lithogenic material, the presumed source of iron, suggests that rapid changes in biological productivity were driven by supply of iron associated with surges in the Patagonian ice sheet that covered much of southern South America during the last glacial period. While this presents a problem for reconstructing past changes in ocean thermohaline circulation, it opens a new opportunity to explore the relative timing of abrupt climate change in the northern and southern hemispheres.

Working with Julian Sachs at MIT we have produced the first evidence for changes in the Southern Ocean associated with Heinrich events. Heinrich Events were times of massive discharge of icebergs into the North Atlantic Ocean. These were the most extreme climate events throughout this region. Temperatures in Europe were colder than during the Last Glacial maximum. Formation of

North Atlantic Deep Water apparently came to a complete halt. It has been surprising that until now no expression of these extreme climate events has been found either in ice cores from Antarctica or in sediment cores from the Southern ocean. We now find evidence for increased biological productivity of Subantarctic waters, both in the SW Pacific, on the Chatham Rise east of New Zealand, and in the SE Atlantic (Cape Basin) that correlate with Heinrich events. Multiple working hypotheses have been developed to explain these relationships, and these will form the basis for future research. Meanwhile, a paper describing these results has been submitted to SCIENCE.

RECONSTRUCTING PAST DEEP SEA CARBONATE ION CONCENTRATIONS

Wallace S. Broecker (LDGO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Establishing the rate of ventilation of the deep Pacific Ocean during late glacial time by measuring the radiocarbon age difference between coexisting benthic (i.e., bottom dwelling) and planktic (i.e., surface dwelling foraminifera).

APPROACH/EVALUATION AND METHODOLOGY

The coarse fraction from large (50 gm) samples from deep-sea cores is isolated and cleaned. Then several hundred whole shells are picked for each of four different planktic species and for mixed benthics. The large size of the samples is dictated by the rarity of benthics. The handpicked forams are then sent to an AMS laboratory for ^{14}C dating.

RESEARCH ACCOMPLISHMENTS

During the past year, efforts concentrated on finding cores which yield bias-free radiocarbon ages on glacial age coexisting benthic and planktic foraminifera shells. This has turned out to be a complicated task. In addition to concerns about contamination with secondary calcite and with the abundance gradient-bioturbation couple, we have identified two other problems. First, differential dissolution occurring within the sediment mixed layer creates age offsets. Second, we have recently come to suspect the reliability of cores stored dry in the LDEO repository. It may be that the concentrated brines generated in the sediment pores during the drying process lead to the deposition of secondary calcite.

Nevertheless high accumulation rate (stored wet) from the western Pacific are yielding excellent results. We have a paper coming out in *Science*, which reports these findings.

MOUNTAIN SNOWLINES OF THE SOUTHERN HEMISPHERE

George H. Denton (LDGO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Determine the timing and magnitude of millenial-scale climatic oscillations in middle latitudes of the Southern Hemisphere.

APPROACH/EVALUATION AND METHODOLOGY

Field mapping of moraines in New Zealand and Patagonia, calculation of mountain snowline changes registered by moraines in New Zealand. Radiocarbon dating of glacial stades and interstades in New Zealand. Comparison of snowline and ice-core records in East Greenland.

RESEARCH ACCOMPLISHMENTS

A digitized glacial geomorphic map of two thirds of the Southern Alps of New Zealand was produced. Along with this effort, a geologic map has been contructed for the same area. The glacial geomorphic map served as the basis for detailed snowline reconstructions for moraines in 10 valleys on the eastern flank of the Southern Alps. Relative to today's value, snowline depression was 674 m at the last glacial maximum (LGM), 447 m at the peak of the late-glacial reversal, and 168 m for the A.D. 1862 extent of the Little Ice Age. These values afford targets for modeling efforts to reconstruct Southern Hemisphere response to, for example, lowered atmospheric CO_2 at the LGM.

The radiocarbon dating program for LGM moraines in the Southern Alps was extended to the Lyndon Creek section alongside the Rakaia Valley, which drains eastward from the mountain divide. When ice filled the Rakaia Valley at the LGM, a lateral ice tongue from the main valley projected into the Lyndon tributary. Meltwater streams from this lobe escaped eastward into the Castle Rock drainage, and in so doing flooded the floor of the Lyndon Valley with outwash. When the main Rakaia glacier pulled back from its LGM position, this outwash was left stranded in the Lyndon tributary valley. Rapid fan deposition trapped organic material on top of the outwash. The resulting date of 21,000 ^{14}C yr B.P. affords a close limit for ice recession from the Rakaia LGM position. At the Kamaka site, the advance to the LGM position is dated to 22,500 ^{14}C yr B.P. In addition, a set of 16 wood samples, each with a complete bark cover, was collected from the Canavan Knob site near the Waiho Loop moraine just west of the Alpine Fault. The purpose is to obtain a more precise chronology of the late-glacial advance of Franz Josef Glacier than now available. Five dates have been processed: 11,150 ± 35; 11,000 ± 45; 11,150 ± 50; 11,050 ± 40; and 11,150 ± 55 ^{14}C yr B.P.

A coring program was undertaken in Quagmire bog and Windy Tarn in the upper Rakaia drainage at 900 m elevation. The purpose was to undertake pollen and chironimid analyses to determine if the results now emerging from the Boundary Stream core, also at 900 m, from the Pukaki drainage. The Boundary core has a chronology controlled by 12 AMS radiocarbon dates. The pollen record shows a grass peak, inferred as a cold reversal, between 12,300 and 11,000 ^{14}C yr B.P. The chironimid record suggests warming beginning shortly after 11,000 ^{14}C yr B.P. and continuing into the Holocene. These results are potentially so important that replication must be attempted at Prospect Hill.

Finally, field-work was carried out in the Lago Argentino area of the South Patagonia Icefield. The purpose was to obtain radiocarbon dates of the Punta Bandera moraines, long recognized as the type late-glacial moraines of southern South America. The results show that the outer Punta Bandera moraines date to 11,160 ^{14}C yr B.P., and hence are several centuries older than the beginning of the Younger Dryas cold reversal in the Northern Hemisphere.

SOUTHERN OCEAN MODERN OBSERVATIONS

Arnold L. Gordon (LDGO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Develop testable hypotheses of mechanisms for climate variability in the Southern Ocean by: establishing and maintaining time-series measurements in the critical outflow region of the Weddell Gyre, and by assembling, inspecting, and critically analyzing all historical hydrographic data from the regions of deep and bottom water formation in the Southern.

APPROACH/EVALUATION AND METHODOLOGY

Time series measurements of current, temperature, and salinity are being made at 3 mooring sites in the Northwest Weddell Sea. These moorings, first deployed in 1999, have been maintained from cruises of opportunity on vessels carrying out unrelated research in the area, funded by NSF and the Brazilian Antarctic Program. Servicing the moorings was accompanied by simultaneous repeat CTD tracer stations across the outflowing limb of the Weddell Gyre. Owing to the reliance on vessels of opportunity for the mooring work, it has been 3 years now since vessel scheduling and ice conditions permitted data recovery and

redeployment. Efforts in 2003 and 2004 were thwarted by severe ice conditions in the project area. Efforts to procure vessel time in late 2004-early 2005 are ongoing.

RESEARCH ACCOMPLISHMENTS

The export of dense shelf water from the Weddell Sea, Antarctica is being monitored by three moorings anchored within the northwest Weddell Sea (south of the South Orkney Islands) as part of the ARCHES program. The ARCHES moorings, installed in April 1999, provide a time series of the combined outflow (currents and temperature/salinity) of a variety of Antarctic bottom water types drawn from various sites along the continental margins of the Weddell Sea. Analysis of the near-bottom potential temperature, salinity and current time series at the deepest of the moorings, M3, reveals significant variability. The coldest outbreak of bottom water from April to July 2001 is associated with higher bottom speeds towards the east and higher salinity. This suggests an impulse of the saline bottom water type derived from the southwest corner of the Weddell Sea. The observations imply significant changes in the production rate of the Weddell Sea bottom types, presumably brought about by changes in the wind and sea ice features that produce and export dense shelf water.

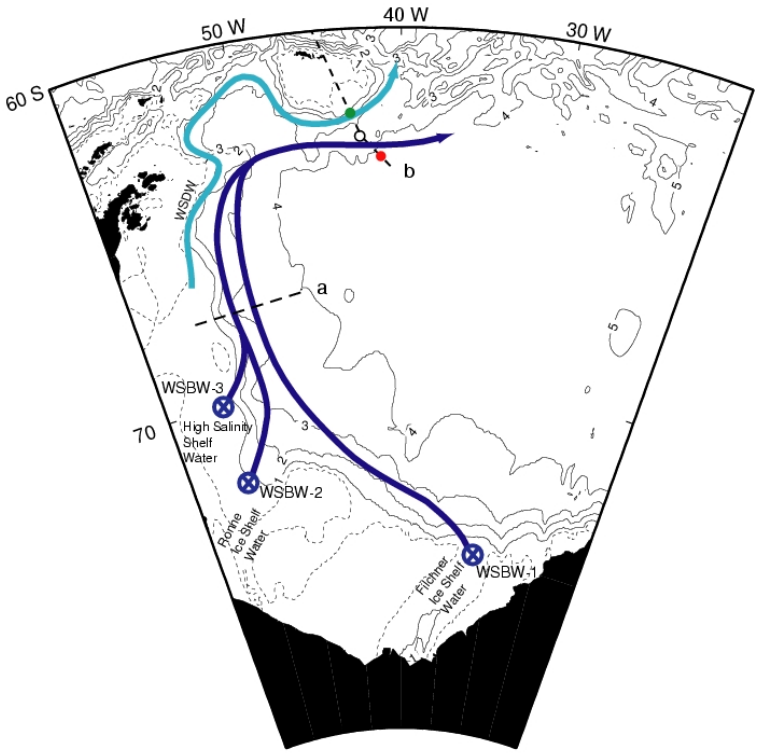


Figure 1. The CORC-ARCHES moorings and repeat CTD tracer section (b). Key formation regions and pathways of deep and bottom water are shown schematically.

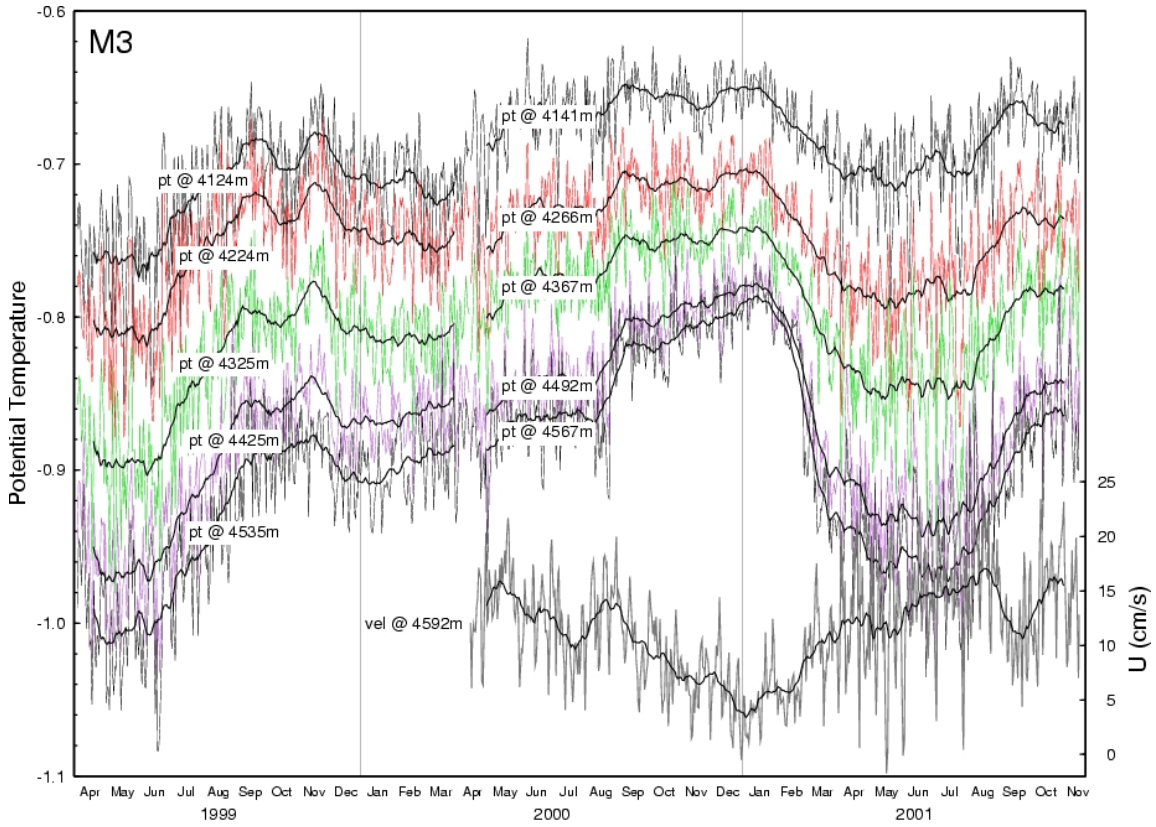


Figure 1. Potential temperature and east-west velocity data from CORC-ARCHES mooring M3, positioned at 63.52°S, 41.79°W, in approximately 4600 m of water.

ACCELERATOR MASS SPECTROMETRIC ANALYSES OF RADIOCARBON

John M. Hayes (LDGO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

During the reporting period 1 July 2003 – 30 June 2004 analyses of radiocarbon for ARCHES investigators. Of these, 15 were analyses of ^{14}C in organic carbon and 81 were analyses of carbonate minerals. Submissions of samples are continuing. Analyses needs to be completed after 30 June 2004. Turnaround times are presently less than two months.

CONSTRAINING CHANGES IN WINDS, THE CONVEYOR AND LOCAL CURRENTS DURING PERIODS OF ABRUPT CLIMATE CHANGE

Sidney Hemming and Steve Goldstein (LDGO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Develop a data set of terrigenous sediment provenance and radiogenic isotope compositon of the ferromanganese fraction of seawater for Holocene, LGM and Stage 3 in order to constrain changes in the winds and shallow and deep ocean circulation during periods of abrubt climate change. The goals require searches for cores where a reliable stratigraphy can be obtained (a central objective of the past year) as well as processing the sediments to (1) remove the fraction coarser than 63 microns, (2) leach away the calcium carbonat, (3) leach away the ferrromanganese fraction (this is retained for studying the dissolved Nd isotope composition of past bottom water, and (4) +/- remove the opal and (5) dissolve and process the sample for isotopic (Nd, Sr, Pb) and elemental analysis. During our year 4 (started Jan 1, 2004) we have made our main focus high resolution records from the eastern North Atlantic.

APPROACH/EVALUATION AND METHODOLOGY

The project is observational, and the main objectives during this year are to(1) identify good cores and devleop reliable stratigraphies, and continue with mapping the Holocene and LGM variability in terrigenous provenance (2) develop a high resolution record of dissolved Nd composition from the Cape Basin, and (3) to begin a high resolution study linking atmosphere, ocean circulation and ice rafting events in the eastern North Atlantic. In the South and tropical Atlantic the task identifying good cores has been led by our graduate student Allison Franzese. New graduate student Kevin Jones has been extending the study of terrigenous sediment composition. Alex Piotrowski (finishing graduate student) has been working on the high resolution record in the Cape Basin from the present back to Stage 5. In the North Atlantic, our post doc Martin Roy has been working on the stratigraphy for a potentially super high resolution core that we obtained as participants in a NERC cruise on the Marion Dufresne in June 2004. We have sampled and measured density and magnetic susceptibility in the interval of ~20 to 40 ky, and are in the process of sieving samples. The eastern North Atlantic project is in collaboration with Ian Hall (Cardiff University, and the chief scientist of the cruise). People involved are the PIs, Millie Mendelson (lab tech), Alex Piotrowski (Ph.D. student), Allison Franzese (Ph.D. student), Keving Jones (Ph.D. student), and Martin Roy (post doc). Additional participants are undergraduate intern David Zylberberg (incoming graduate student this fall) and Liz Knapp (Tappan Zee High School sophmore). David worked with Alex Piotrowski on the dissolved Nd measurements, and Liz has been working with Martin Roy on the eastern North Atlantic core.

RESEARCH ACCOMPLISHMENTS

We have identified a number of good cores, and are continuing with our suvey of the pattern of terrigenous provenance in the Holocene and LGM. Results from the Cape Basin and aournd the tip of South Africa are near completion and Allison Franzese should be submitting a paper on this work in the near future. Kevin Jones will be writing his masters paper on his more (geographically) extensive survey, due in Feb. 2005. Allison Franzese has identified a few more cores in the South Atlantic region and has found a number of high quality cores in the tropical Atlantic. She is trying to determine if the variations in focussing factor (comparing the sediment flux based on stratigraphic age with the flux based on normalizing to excess 230Th as a constant flux proxy), which are high near the equator, may be used to constrain the position of the intertropical convergence zone. Preliminary results will be presented at ICP9 in Biarritz, FR in September. The results from Alex Piotrowskin are spectacular (and will also be presented at the ICP8 meeting in two posters and Steve Goldstein's invited talk), and show variability of deep water composition that appears well correlated to Greenland temperature records. Our interpretation is that the deep water composition is responding to changes in NADW production which are in turn responding to climate forcing in the North Atlantic.

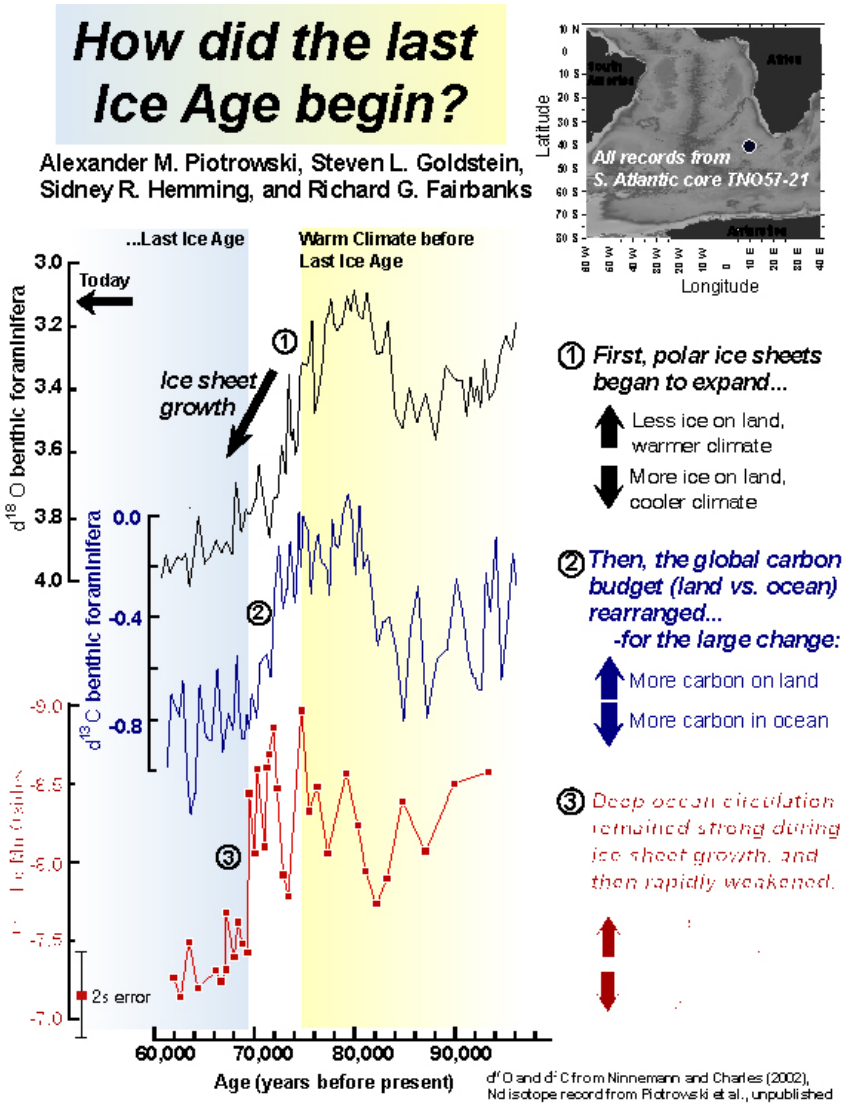


Figure 1. The temporal sequence of changes in paleoclimate and paleoceanography records is key to distinguishing the processes that force global climate change from those that react to or enhance these changes. All of the records in this figure were measured on the same high sedimentation-rate core (TNO57-21; see map), thus allowing direct comparison without chronological ambiguities. During the period of time showed in this figure (Marine Isotope Stage 5a - 4 transition; ~75 to 70 kyr ago), global climate shifted from relatively warm interglacial conditions (yellow highlight) to a full ice age (blue highlight). Continental ice sheets in the polar northern hemisphere expanded causing a rapid and large-scale global sea level lowering. The growth of continental ice sheets is the primary cause of the gradual change in the oxygen isotope record (black record; $\delta^{18}O_{\text{benthic foraminifera}}$; during this interglacial-to-glacial climate transition. The start of ice sheet growth ***(1)*** is followed by a large shift ***(2)*** in the carbon isotope record (blue record; $\delta^{13}C_{\text{benthic foraminifera}}$; a few thousand years later. A shift of this magnitude in the carbon isotopic composition of the deep ocean requires a change in the balance of organic carbon stored in the terrestrial biosphere versus the deep ocean. Only after the growth of large continental ice sheets and a reorganization of the global carbon budget, does our new Nd isotope record (ε_{Nd} of Fe-Mn oxides; red record) indicate a long-term reduction in deep ocean circulation ***(3)***. This sequence of events implies that a shutdown of deep ocean circulation did not trigger the ice sheet growth and global carbon budget reorganization which occurred at the start of the last ice age. Instead, it suggests that strong

ocean circulation in the Atlantic Ocean sustained during cold climate conditions may have provided an important source of moisture for continental ice sheet growth.

MECHANISMS OF ABRUPT CLIMATE CHANGE

Richard Seager (LDGO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Basic objective is to understand the causes of past abrupt climate changes and to determine their future possibility. The research project particularly focuses on how reorganizations of tropical climate, such as shifts in the character of the El Nino-Southern Oscillation, or in the tropical ocean and atmosphere heat transports, can cause global changes in climate. The principal idea is that these reorganizations cause changes in clouds and water vapor that effect the planet's albedo and greenhouse trapping; tropical climate reorganizations will also force changes in global atmosphere circulation that will cause regional climate changes.

APPROACH/EVALUATION AND METHODOLOGY

The work involved analysis of modern observations, proxy evidence of past climates and simulations of past, present and future climates. We engaged in major activities to understand the role of ocean heat transport, in both the tropics and mid-latitudes, in determining the Earth's climate and how it changes. We also engaged in a major activity to understand the causes of obvious and rapid climate changes in recent history, such as that in 1976/77, and to determine their predictability. We also examined the means whereby changes in tropical climate impact climate in the remainder of the world emphasizing a new idea that can cause zonaly and hemispherically symmetric climate change and which is related closely to mid-latitude droughts, This lead us to begin a major study of the causes of persistent droughts and pluvials over North America. All of these investigations involved analyses of instrumental records, proxy evidence and numerical simulations.

RESEARCH ACCOMPLISHMENTS

In the last year we have proposed an explanation for why the presence of ocean heat transport warms the global mean climate. This involves an interaction between the atmosphere circulation, the atmospheric water vapor content and the low-level cloud cover. This work suggests that changes in the partition of the total heat transport between atmosphere and ocean will impact the mean temperature of the planet. We are working on what controls this partitioning. We have one paper submitted for publication addressing the origins of the tropical warm pools. regions of enhanced greenhouse trapping, and how they relate to ocean and atmosphere heat transports. Another submitted paper examines decadal timescale changes in tropical atmosphere and ocean heat transport and how they relate to the climate changes of the last century.

We have also extended our previous studies of the mechanisms of zonally and hemispherically symmetric climate variability to consider the impact on precipitation. This work has shown that dramatic climate events such as the Dust Bowl drought of the 1930s, the extremely wet 1977 to 1998 period in most of North America, and the current drought in the West, are part of a global pattern of precipitation anomalies forced by tropical Pacific sea surface temperature variations.

Further, we have shown that the tropical Pacific sea surface temperature variations that cause these droughts and pluvials are predictable, to a limited extent, years in advance. We have carried out experimental forecasts of the 1998 cold shift in the tropical Pacific and hind-casts of past tropical Pacific climate shifts.

We have begun to extend the work on recent rapid changes in tropical climate and North American hydrology into the more distant past and are pursuing the idea that the chronic dryness of the American Southwest in Medieval times was caused by persistent La Nina conditions at that time.

MODERN OBSERVATIONS

William M. Smethie, Jr. (LDGO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

- The overall long-term objective of this project is to better understand mechanisms of deep and bottom water formation, deep mixing, and thermohaline circulation and to improve representation and parameterization of these processes in ocean circulation models. The specific objectives are:
- Investigate the current state of the ocean's thermohaline circulation with particular emphasis on documenting interannual variability in water mass formation at major sites in the Southern Ocean and the coupled North Atlantic/Nordic Seas/Arctic Ocean system.
- Maintain and optimize the boundary current observing system in the Weddell Gyre outflow region in collaboration with the international community.
- Interpret the new data in the context of historical data sets.
- Provide observations that can be used to improve the representation of deep water formation processes in state of the art climate (ocean) models.

Meeting these objectives requires a multi-year observational and data synthesis effort. The results and activities presented in this progress report are for only the one-year period from July 2003 to August 2004.

APPROACH/EVALUATION AND METHODOLOGY

The basic approach of this project is to make measurements in regions where deep and bottom water form and in regions where these dense waters enter the deep ocean circulation. The particular measurements my component of this research focuses on are chlorofluorocarbons. Other ARCHES PIs provide measurements of temperature, salinity, tritium, helium isotopes, oxygen isotopes, current velocities and moored hydrographic observations at select sites. The anthropogenic chlorofluorocarbons, CFC-11, CFC-12 and CFC-113, have well known atmospheric time histories and enter the ocean only at the surface. They provide information on the location and age of newly formed deep and bottom water, the extent that this water interacts with the atmosphere prior to sinking, and entrainment of older subsurface waters during the sinking process. The primary regions of concern are where deep and bottom water form are the northern North Atlantic and around the Antarctic continent. The ARCHES Modern Observations program places more emphasis on the regions around Antarctica where the least is known. Here we have two observational strategies: 1) monitor the deep and bottom water outflow from the Weddell Sea with a hydrographic/tracer line occupied annually to document and investigate its annual to decadal variability and 2) make tracer measurements on ships of opportunity to sparsely sampled shelf regions of the Antarctic continent to investigate deep and bottom water formation in these regions. We also maintain a database of earlier data from the Antarctic shelf and coastal seas for comparison with our new data and to examine for temporal trends. For the North Atlantic, we augment on-going time series programs in regions of deep-water formation, with tracer observations. The tracer data provide information on rates and pathways of deep and bottom water formation, but just as importantly they also provide observations to test and refine ocean circulation models.

Specific research activities for the June 2003 – July 2004 year are described below.

- Submitted a manuscript entitled "Circulation and melting under the Ross Ice Shelf: Estimates from evolving chlorofluorocarbon and salinity fields in the Ross Sea" for publication. I collaborated with S. Jacobs of LDEO on this manuscript and H. Lee of LDEO helped with the data analysis and preparation of figures.
- Collected CFC samples in flame sealed glass ampoules on the LMG04-04 cruise to the mooring site for deep outflow from the Weddell Sea. As for the previous year it was not possible to recover the moorings or complete the hydrographic/tracer section because of heavy ice cover. Instead, stations that had been taken the previous year in passages in the South Scotia Ridge through which some deep water flows northward from the Weddell Sea, were reoccupied to examine interannual variability. About 130 samples were collected by D. LeBel of LDEO.

- Collected CFC samples in flame sealed glass ampoules on the 2003 summer and fall and 2004 winter and spring cruises of the Iceland Marine Research Institute in Denmark Strait and north and south of Denmark Strait. These samples were collected by Magnus Danielsen of the Iceland Marine Research Institute. This sampling program was started at the beginning of 2002. Four CTD surveys per year are conducted by the Iceland Marine Research Institute. This provides time series observations of CFCs in Denmark Strait Overflow Water at its point of entry into the North Atlantic as well as upstream and downstream of this point of entry. The data will be used to investigate seasonal and interannual variability in the formation and input of Denmark Strait Overflow into the North Atlantic. This work is being done in collaboration with Jon Olafsson of the University of Iceland and the Iceland Marine Research Institute.
- Analysis of CFC samples collected from the 2002 summer and fall cruises and the 2003 winter and spring cruises of the Iceland Marine Research Institute. These samples were measured at LDEO by E. Gorman and M. Stellato (an undergraduate student).

RESEARCH ACCOMPLISHMENTS

Temperature, salinity and chlorofluorocarbons (CFCs) 11, 12 and 113 were measured on a line of stations along the front of the Ross Ice Shelf in the austral summers of 1984, 1994 and 2000. Water mass distributions were similar each year but with high variability in the cross-sectional areas. CFC concentrations increased and salinity decreased with time throughout the water column. CFC saturation levels in the shelf and surface waters also increased with time and ranged from 43 – 90%. The undersaturation was due to inflow of low-CFC modified Circumpolar Deep Water, gas exchange limited by sea ice cover and isolation of water from the atmosphere beneath the ice shelf. The residence time of dense shelf waters resulting from sea ice formation is less well constrained by the chemical data than is the strong flow into the Ross Ice Shelf cavity. Shelf waters are transformed over about 3.5 years, by net basal melting of the ice shelf, into fresher Ice Shelf Water (ISW), which emerges as a large plume near the central ice front at temperatures below the sea surface freezing point. We estimate an average ISW production rate of 0.86 Sv and an average net basal melt rate of 60 km^3/year for the Ross Ice Shelf exceeding a 300 m draft (75% of the ice cavity) during recent decades from box and stream tube models fit to all of the CFC and salinity data. Model fits to the individual data sets suggest ISW production and net basal melt rate variability due to interannual changes on a shorter time scale than our observations. ISW production based on the CFC budget is better constrained than net basal melting based on thermohaline data, with a heat budget yielding a rate of only 20 km^3/yr. Reconciling differences between apparent freshwater and temperature changes under the ice shelf involves considerations of mixing, freezing and the flow of meltwater across the ice shelf grounding line.

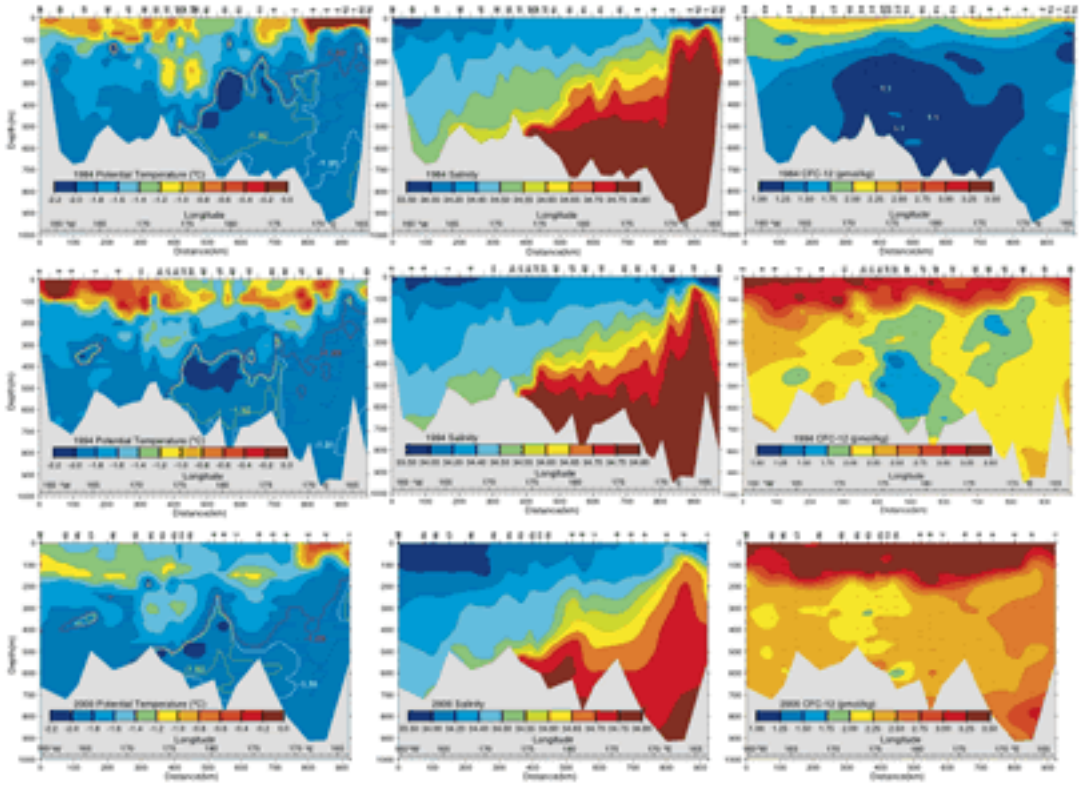


Figure 1. Vertical sections of potential temperature, salinity and CFC-12 concentrations along the front of the Ross Ice Shelf in 1984, 1994 and 2000. The view is southward looking into the ice shelf cavity. Ice Shelf Water is identified as a region with water colder than the freezing point at atmospheric pressure (<-1.92°C) in the central part of the section. The CFC-12 concentration in this cold water is lower than in adjacent waters because of the time the water has been isolated from the atmosphere beneath the Ross Ice Shelf. High Salinity Shelf Water is apparent as high salinity water on the western side of the section. Salinity decreases with time because of the regional freshening trend and CFC-12 increases with time because of its increase in the atmosphere.

EASTERN PACIFIC COLD TONGUE-ITCZ VARIABILITY OVER THE LAST 30 KY

Jean Lynch-Stieglitz (LDGO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Reconstruct variability of the cross-equatrial front between 0º-10ºN in the eastern Pacific since the last glacial maximum. Link it to the dynamics of the Intertropical Convergence Zone (ITCZ), and assess the influence of ITCZ shifts on the strength of the cold

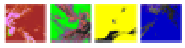
tongue and the equatorial upwelling. The plan has been to measure Mg/Ca and oxygen isotopic ratios (proxies of sea surface temperature and salinity) in fossil foraminifera from deep sea cores in a north-south transect across the cold tongue-ITCZ front.

RESEARCH ACCOMPLISHMENTS

With the goal of reconstructing and understanding long-term climate variability in the eastern tropical Pacific, we have pursued paleoceanographic reconstructions along a north-south ocean transect between ~ 8ºN and 3ºS, utilizing shallow-to-intermediate depth cores located on the Cocos and Carnegie Ridges, north and east of the Galapagos Islands. Building on the observed spatial patterns of modern hydrographic variability in the cold tongue-Inter-tropical Convergence Zone (ITCZ) system of the eastern Pacific we have developed a strategy for tracking ITCZ variability and its impact on equatorial upwelling on millennial-to-orbital timescales. The strategy relies on reconstructing the intensity of the meridional sea surface temperature (SST) front north of the equator, which separates the equatorial upwelling zone from the ITCZ to its north. A strong front accompanies enhanced upwelling and northward ITCZ displacement, while a weak front accompanies suppressed upwelling and equatorward ITCZ shifts. This front can be monitored effectively by both the oxygen isotopic composition and the Mg/Ca elemental ratio of planktonic foraminifera, the former being a combined SST-salinity proxy, while the latter primarily a SST proxy. Our objective has been to assemble sufficient $\delta^{18}O$ and Mg/Ca records to resolve the spatial structure of the oceanographic front and its temporal evolution over the last 30 ky.

In 2003 we completed three new down-core Mg/Ca records in sites V21-30 (1.2ºS, 89.6ºW, 617 m), V19-28 (2.4ºS, 84.6ºW, 2720 m) and RC13-140 (2.8ºN, 87.7ºW, 2246 m). We also completed the $\delta^{18}O$ record of *G. ruber* from V21-30. With the advent of these new data we now have robust records of SST and $\delta^{18}O$ variability south of the equator, in the heart of the equatorial cold tongue (sites V21-30 and V19-28). We have refined our constraints of glacial-interglacial SST variability in this globally influential upwelling system. Our current best estimate for last glacial maximum (LGM) SST drop is 2.0±0.5ºC. The new data confirm the presence of a cooler early-mid Holocene which we previously proposed on the basis of *G. sacculifer* Mg/Ca data from V21-30. We believe this result is highly useful for understanding the Holocene evolution of ENSO, among other things. Moreover, we have some compelling indications from both $\delta^{18}O$ and Mg/Ca that the LGM front structure was weaker than the Holocene, which we interpret as the result of a southward shift of the Pacific ITCZ, similar to what other studies have observed for the Atlantic ITCZ.

Current work is focusing on similar reconstructions from two sites at latitudes of 7°N and 10°N. These are influenced by the northerly extreme of the ITCZ during boreal summer and will be used to constrain the northern range of the ITCZ over the past 30,000 years.



THE ARGO PROJECT: GLOBAL OCEAN OBSERVATIONS FOR UNDERSTANDING AND PREDICTION OF CLIMATE VARIABILITY

Dean Roemmich and Russ Davis (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The Argo array will provide unprecedented real-time views of the evolving physical state of the ocean. It will reveal the physical processes that balance the large-scale heat and freshwater budgets of the ocean and will provide a crucial dataset for initialization and assimilation in seasonal-to-decadal forecast models. (http://www.argo.ucsd.edu)

APPROACH/EVALUATION AND METHODOLOGY

SIO is one of 5 institutions responsible for the full implementation of the U.S. component of the international Argo project. U.S. Argo produces and deploys about 400 floats per year, collaborating with the international program to ensure global coverage. U.S. Argo also maintains a data assembly center for delivery of real-time and research quality (delayed-mode) data from U.S. floats.

The specific roles of SIO-Argo include:

- Production and deployment of 105 floats per year.
- Technical development and improvement of profiling floats for Argo (R Davis).
- Participation in the Argo data system through delayed-mode scientific quality control.

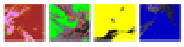
- Leadership of international Argo by J. Gould (Argo Director) and D. Roemmich (Chairman, Argo Science Team), and coordination of the U.S. Argo Consortium (SIO, WHOI, UW, NOAA/PMEL, NOAA/AOML).

RESEARCH ACCOMPLISHMENTS

Implementation: As of June 2004 there are 1303 active Argo floats, 43% of the complete Argo array. Sparse global coverage has now been achieved. All Argo data are freely available from two global Argo data centers, usually within 24 hours of collection, and delayed-mode datasets are now being produced. There are presently 147 active SIO-Argo floats, plus 43 being deployed by R/V Kaharoa.

Science: The foci of Argo research at SIO have included the use of floats for understanding the heat and freshwater budgets of the ocean, water mass formation and variability, improved descriptions of ocean circulation, and techniques for combining *in situ* and satellite datasets. While it is still an early stage in Argo's implementation, research is progressing rapidly to demonstrate the high value of the array for climate and a broad range of other applications.

USS KAHAROA Personnel.



ECONOMIC BENEFITS OF WEATHER AND CLIMATE FORECASTS TO CALIFORNIA ENERGY PRODUCTION MANAGEMENT

Tim P. Barnett (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The purpose of this research is to produce weather and climate forecasts tailored to the energy production industry, and to evaluate the economic benefit of those forecasts. We plan to achieve this by assessment of climate related needs of key energy industry decision makers, then producing, evaluating the skill of, and distributing forecasts to address those needs. The results will be given directly to the relevant energy industry personnel in addition to being published in the scientific literature.

APPROACH/EVALUATION AND METHODOLOGY

The two objectives were broken down into specific tasks, notably:

Objective 1: Produce and evaluate skill of weather and climate forecast variables important to energy supply and demand:

- Assess weather-related issues if importance to energy industry
- Identify weather/climate information needed to address these issues
- Produce operational 0-7 day weather forecasts for the energy industry
- Produce 0-14 day hindcasts for energy industry
- Produce seasonal forecasts for the energy industry
- Iterate to produce optimal weather/climate forecasts
- Evaluate the skill of the climate forecasts

Objective 2: Quantify the economic benefit of weather and climate forecasts

- Identify key weather/energy scenarios
- Evaluate climate connections between California and the Pacific Northwest
- Calculate the economic benefit of various strategies used during the scenarios
- Evaluate the sensitivity of the business forecast to the weather forecast
- Evaluate the economic benefits of the weather-enhanced business forecast

RESEARCH ACCOMPLISHMENTS

The California Energy Security Project ("CalEnergy") has resulted in four primary accomplishments. First, we produced weather and climate forecasts tailored to energy agencies and utilities, and evaluated the skill of those forecasts. Second, we established collaborative relationships with energy partners, including utilities and government agencies, and identified the types of decisions and the decision-makers that could potentially benefit from these forecasts. Third, we worked directly with users to integrate those forecasts into decision-making, which involved an iterative process of communicating and refining forecasts products to meet user needs. Fourth, we evaluated the net economic benefits of using that forecast information, relative to existing information.

Examples of the forecast projects we have worked on are:

a. Working with the California Independent System Operator (Cal ISO), we calculated that a reduction of forecast error in the California central valley from the current 3.05^{o} F to 2.7^{o}F would reduce weather-related error costs from $10M to $8M/year. We designed a series of statistical correctors to the weather forecast data that are optimized to reduce the biases in the forecasts that incur the greatest costs for them (and, hence, ratepayers). We designed a forecast for likelihood of the "delta breeze" (which greatly influences their electrical load), which is in the process of going operational.

b. We worked with San Diego Gas & Electric to develop a forecast scheme for calling peak load demand management days (days when electrical load is anticipated to be one of the 12 highest days per summer). This scheme nets 6% greater electrical use on forecast days than average days over the period 1990-2003,

compared to the maximum possible (based on temperature forecasts) of 12%. This is better than had previously obtained and obtains half the maximum possible.

c. We worked with PacifiCorp (a large utility in the Pacific Northwest) to forecast the total electrical load expected from irrigation pumps over the summer season. We found some skill using soil moisture and precipitation in the spring to forecast this value. This project is ongoing, but we expect this will help them optimize their operational processes.

d. We have estimated that fluctuations in the North Pacific Oscillation (NPO) climate phenomenon can make a $220M difference in residential and commercial natural gas heating bills over the winter.

e. We have developed an extensive set of forecast products for the California Energy Commission, which should help them in their job of steering California's electricity utilities towards ways of operation that have the greatest reliability at the least expense.

Another important outcome of this project has been scientific outreach: By working directly and continuously with potential users of forecast information, we have been able to provide the forecast products that would be most valuable to decision-making, and in turn, user needs have helped to direct the forecast products that were generated. The research has had far reaching significance because weather and climate forecasts provide broad potential to better anticipate and manage fluctuations in energy supplies and demands

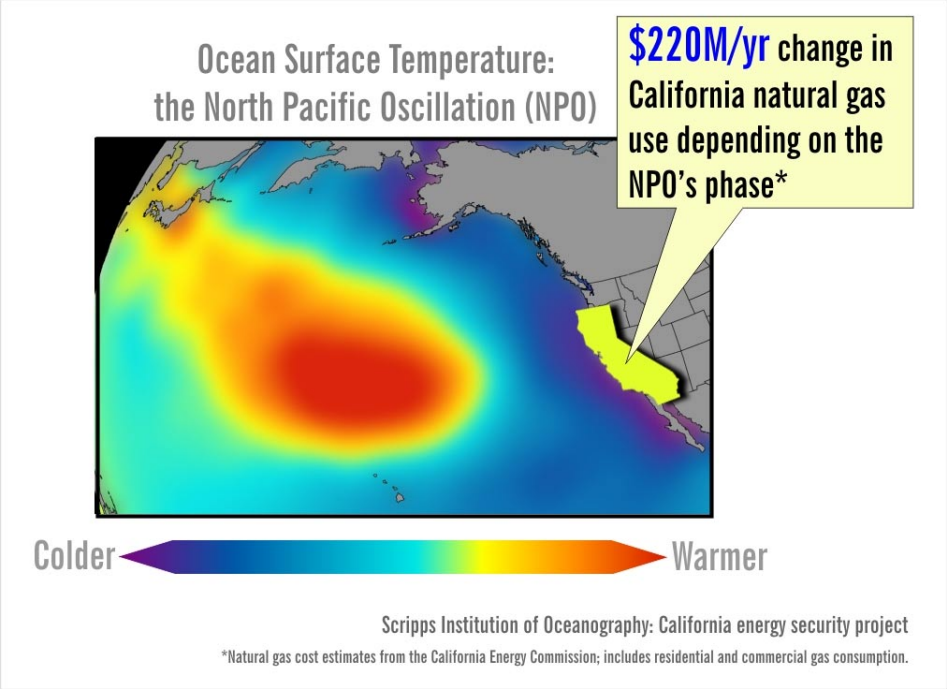
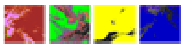


Figure 1. The large-scale climate fluctuation known as the North Pacific Oscillation (or Pacific Decadal Oscillation) can bring either warm or cold conditions to California in the winter. The difference in natural gas use for space heating between these two phases can be about $220 M/yr.



INTERIM AND CONTINUATION FUNDING TO MAINTAIN THE TIME-SERIES OF THE CALIFORNIA COOPERATIVE OCEANIC FISHERIES INVESTIGATIONS

Elizabeth L. Venrick (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management; Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) is a partnership among National Marine Fisheries Investigations, Scripps Institution of Oceanography and California Department of Fish and Game that maintains the longest marine ecosystem-observing program in North America. Plans are underway to create a coast-wide ecosystem observing system (PaCOOS) that would include CalCOFI as a component. These JIMO funds provided support to the CalCOFI technical staff and continue the time series while PaCOOS is under development.

APPROACH/EVALUATION AND METHODOLOGY

The time series is built from quarterly cruises that make hydrographic and biological measurements in the Southern California Bight, documenting physical variability and changes throughout the ecosystem from phytoplankton to fish, birds and mammals. This reporting period included four cruises. Technical support was provided by SIO and by SWFSC/NMFS. Ship-time was provided by NOAA (SWFSC and JIMO).

RESEARCH ACCOMPLISHMENTS

CalCOFI data are used for diverse projects. Because the data is publicly available, it is impossible to know every use. The focus of the program itself is the long-term, large-scale changes in the oceanography of the region, their links to climate variability and their effects on the ecosystem. Many of our observations are used directly or indirectly in local management decisions for fish and invertebrates. During this reporting period, we observed a relatively minor El Nino event which was short-lived in our region and had little, if any, ecosystem consequences. Supermposed upon this was an anomalous southward intrusion of Sub arctic water. This was first recognized off Oregon, where it enhanced the nutrient content of coastally upwelled water and stimulated an unusually dense bloom of phytoplankton. The intrusion was seen as far south as southern California where it may have increased the phytoplankton biomass of offshore waters.

Because of the length and completeness of the data, past fluctuations of key fisheries, such as the small pelagic species and, most recently rockfish and market squid, are being evaluated in the context of concomitant ecosystem changes. The harvest formula for the California sardine now adjusts the quota to account for recent ecosystem change and the expected population response. The oceanographic data are being used to calibrate satellite instruments and to initiate and confirm regional ocean models.

The CalCOFI partners are participating in plans to create a west coast ecosystem-observing program: Pacific Coast Ocean Observing System (PaCOOS). This will coordinate and strengthen existing species-driven monitoring programs along the entire coast, allowing populations to be studied throughout their ranges. In addition to the three CalCOFI partners, PaCOOS will include the NWFSC/NMFS, the state agencies of Oregon and Washington, several academic institutions of California, Oregon and Washington and the Point Reyes Bird Observatory, in Monterey.

THE GLOBAL DRIFTER PROGRAM

Peter Niiler (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The "Global Drifter Program" (*GDP*) is the principal component of the *"Global Surface Drifting Buoy Array"* of the NOAA Ocean Observing System for Climate and a scientific project of the DBCP of WMO/IOC. It is a near-operational ocean-observing network of drifters that, through ARGOS, returns data on ocean currents, SST and atmospheric pressure (and winds and salinity) and provides a data processing system for scientific utilization of these data.

The scientific objectives of the *GDP* are to:

- Provide an operational, GTS data stream of SST and sea level pressure.
- Measure the mixed layer velocity on a global basis with 5° resolution and produce new charts of the seasonal and interannual changing circulation of the world ocean.
- Develop and introduce into the drifter construction technological advances in sensors, electronics, power, methods of assembly and deployment packaging.
- Provide enhanced data sets of ocean circulation that include drifter data from individual research programs, historical data from different drifter types and the corrected data sets for wind-produced slip of drifter velocity.

APPROACH/EVALUATION AND METHODOLOGY

Since 1992, there have been about 600 drifters in the global array. Based on requirements of computing an accurate SST map of the global ocean with the combination of satellite and insitu data, an array of 1250 drifters is required. The full implementation of the drifter array is now feasible now because over the past 10 years its principal instrument, the SVP Lagrangian Drifter and its barometer attachment (SVP-B), has proven to be reliable and affordable. A drifter array provides data for more than 450 days of operation at sea, is easily deployed from ships or aircraft and is manufactured commercially by three US firms at a cost of 1/3rd of what it was ten years ago. In FY 2004 the drifter array has increased to about 1000 elements (1031 elements on 8/16/04) and by June 2005 the desired 1250 element array will be in place. JIMO works in close cooperation with AOML/NOAA to achieve these objectives.

International operational oceanographic and meteorological agencies also contribute significantly to the purchase and deployment of the global SVP drifter array because *GDP* has developed a close working relationship with them both individually and through DBCP. DBCP reports on the activities of the *GDP* directly to IOC and WMO, via its membership in the Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology (JCOMM). The *GDP* operational partners are the meteorological agencies of New Zealand, Australia, South Africa, Great Britain, France, India, Korea, Canada, US and Brazil and the International Ice Patrol, NAVOCEANO, ONR and CICESE/ Mexico. Working with these partners through DBCP (and JCOMM), a 100% completion of the *"Global Surface Drifting Buoy Array*" is expected.

RESEARCH ACCOMPLISHMENTS

Drifter Acquisitions

In 2003 666 SVP-Mini drifters were purchased, with 115 upgrades to SVP-Bs. In addition, AOML purchased 41 SVP-Mini drifters. In cooperation with ONR and the Busan National University in Korea, 80 SVP-Mini drifters and 14 Minimet wind-sensing drifters were acquired. In a joint project with JIMO and CICESE/Mexico, an additional 90 SVP-mini drifters are being deployed with Mexican into the Gulf of California.

The 2003-4 GDP contribution to the "Global Surface Drifter Array" will be 720 SVP drifters, a significant increase over acquisitions in 2002 (467 drifters); an additional 170 SVP drifters will be deployed in the marginal seas of the Pacific. There will be a significant increase of drifter data in 2004 due to: 1) Office of Global Program (OGP) funding for enhancements of the observing system for the South Atlantic and the North and South Pacific Oceans (purchase on about 900 drifters in FY 2004), 2) the inclusion of research

projects that agreed to allow their data to become part of the GDP operational data file (about 200 drifters) and 3) technology developments of drifter construction which lowered the per-unit price.

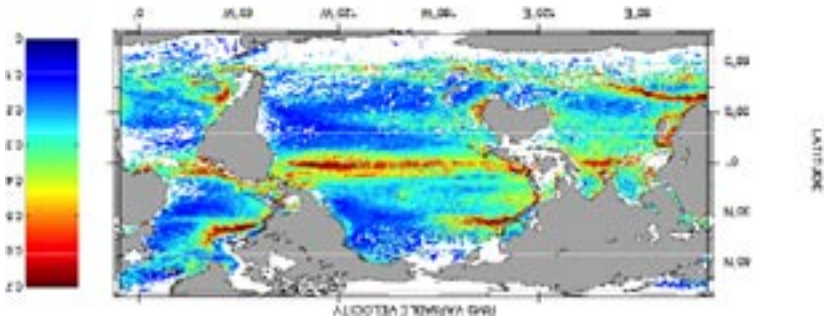


Figure 1. The root mean square of the time variable ocean velocity determined from GDP drifter data from 1988-2003. Drifter observations are the only method by which to observe the global distribution of time variable currents in the equatorial zones.

Technical Developments

- In 2002-03, the configuration of the SVP drifter was redesigned. In 2002, the SVP price was reduced from $2150 to $1950 and reduced further to $1800 in 2003. The anticipated cost of 2004 will be $1750 per drifter, resulting in 23% increase in acquisitions over 2002.
- The SeaBird Microcats were adapted to observe sea surface salintity (SSS) at the bottom of the SVP drifter float; since 2002, 28 SVP-SSS test drifters have been deployed in the East China Sea.
- With the cooperation of ONR, 16 Minimet wind-sensing drifters, using deployment methodology developed by GDP, were air-deployed into Hurricane Fabian in Sept 2003 and 39 drifters in August 2004 into Hurricane Frances.

Coordination with Individual Research Projects and Data Enhancements

Coordination of research programs with the Busan National University of Korea, the NOAA/AMLR program in Antarctica, the Oregon State University climate studies projects and CICESE, Mexico were achieved. Enhanced data sets on 15m drifter velocity were distributed to 37 international research scientists.

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CALIFORNIA APPLICATIONS PROGRAM (CAP)

Daniel R. Cayan (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The goal of CAP is to investigate the physical climate system and its regional impacts in an integrated way so as to provide useful climate information to decision makers (planners, managers and information users) in the California region. CAP's organizing philosophy includes three key elements: 1) a focus on representative key and relevant regional climate issues (water, wildfire, human health and building a regional climate data capacity); 2) an emphasis on improved forecasts and improved reliance on forecasts at seasonal, interannual and long term time scales; and 3) a core team of authoritative disciplinary researchers experienced/adept at linking across disciplines and enlisting a select small set of motivated and fairly high level practitioners in the applications community.

APPROACH/EVALUATION AND METHODOLOGY

The CAP regional climate studies are being conducted with a mind toward regionally important problems that are affected by global climate influences. Thrust areas identified were chosen for their great relevance to decision makers and residents of California and the greater California region. There are two underlying questions that are common issues across virtually all of the components of this work:

Can we identify climate and hydrologic predictive skill at a range of time scales? How can this skill be exploited to the benefit of the water, wildfire and human health sectors? What climate information is needed to inform decision makers in the water, wildfire and human health sectors?

Activities of the three elements (water resources, wildfire and human health) are outlined below. Key components of the activities are also outlined below (forecast methods, regional modeling, and building climate observation capacity). Several of these activities capitalize upon activities that are supported or commissioned by other agencies or collaborators; this exemplifies the connectedness that is being developed at CAP.

Water Resources

Northern California Regional Water Resource Prediction and Management - K. Georgakakos, N. Graham, S. Taylor, T. Carpenter (Hydroclimate Research Center), D. Cayan (SIO)

Testing of a regional distributed hydrologic model (resolution of 200-400 km^2) has begun over a target region of the Sacramento River basin in northern California with an outlet point downstream of the confluence with the American River. A potential theory airflow model, coupled to a simplified microphysical rainfall production model, has been developed and tested for representation of the deterministic signal of the orographic rainfall enhancement caused by the terrain of northern California (article in preparation)

Coastal California Surface and Ground Water Resources - R. Hanson (USGS), M. Dettinger (USGS)

Using existing regional grond-water models (RGWMs), work has begun assessing the statistical skill of employing GCM weather forecasts at 3 to 6 months into the future. In collaboration with CAP scientists K. Georgakakos and A. Gershunov, work has begun on incorporating statistical downscaling techniques to bridge the gap between the GCMs and RGWMs.

Injecting Climate Knowledge and Research into CALFED - M. Dettinger (USGS), D. Cayan (SIO), K. Redmond (DRI)

Assessment of the current state of knowledge about California's climate (as applies to CALFED) and recommendations for climate-science activties and support within the CALFED program has begun. Characterizations of climate variations from paleoclimate proxies, the historical period and in recent climate-change projections are being formulated for communication to CALFED participants and the public.

Wildfire

Seasonal Forecasting and Economic Assessments - A. Westerling (SIO), D. Cayan (SIO)

Progress continues on decision calendars for wildfire and fuels management (with B. Morehouse, CLIMAS, and T. Corringham, SIO). Efforts have begun on incorporating climate assessments in long-range fire management plans. A database of individual fire records is being designed to examine fire suppression effectiveness in contribution to the CEFA initiative to develop and evaluate a climate/weather index for escaped fires in California. With M. Dettinger (USGS), T. Brown (DRI), B. Hall (DRI) and L. Riddle (SIO), a Santa Ana wind index was developed and applied for temporal variability and impact on autumn wildfires in southern California (EOS, in press).

CEFA California Activities - T. Brown (DRI), B. Hall (DRI), A. Westerling (SIO), D. Cayan (SIO)

Evaluation and verification of ECPC weekly to seasonal climate forecast fire weather variables and outreach to GACC fire weather meteorologists for assisstance in utilizing monthly and seasonal climate forecasts in operations continues. Research collaborations with SIO, CLIMAS and other RISA's progresses and fire climate workshops have been planned.

Human Health

Encephalitis (presently funded by OGP Joint Program on Climate Variability and Human Health effort) - B. Reisen (UCD), B. Eldridge (UCD), C. Barker (UCD), D. Cayan (SIO), M. Dettinger (SIO)

This research focuses on how climate variability impacts the temporal and spatial dynamics of vector mosquito populations and the pathogens they transmit. A near-complete assemblage of over 3 million trap nights of data is being examined for relationships among climate variability, mosquito abundance and the activity of WEE and SLE viruses. An initial effort to forecast the risk of virus transmission that may impact the health of California residents has begun.

Building Capacity for Climate Forecasts and Observational Data

Improving Forecasting Methodology - D. Cayan (SIO), M. Dettinger (USGS), A. Gershunov (SIO), A. Westerling (SIO)

Design has begun on a toolkit of techniques to be applied to regional forecast problems. This toolkit includes hybrid statistical/dynamical methods, which have focused on hydrological variables but will be applied to other problems, including wildfire and mosquito populations. Work has also begun on another element of the toolkit, which handles heavy-tailed distributions of daily hydrologic (precipitation and streamflow) data.

Regional Forecast Data Set - M. Kanamitsu (SIO), D. Cayan (SIO)

Four initial years of a 50-year downscaling effort of a high resolution regional reanalysis has been completed. Analysis of this data (presented in June 2004 at the First California Climate Change Conference) reveal several interesting diurnal and seasonal patterns that define unique circulation patterns. Comparison of these initial results with station data has begun.

Observations in California - D. Cayan (SIO), M. Dettinger (USGS), K. Redmond (WRCC), H. Diaz (CDC), C. Millar (USGS)

Efforts continue to move forward in building partnerships, users and capacity for better observational resources. One effort has been CIRCMONT, a high elevation monitoring and research development that spans the western United States. Two productive meetings were held this year: one at the Sierra Nevada Science Symposium (October 2003) and the other at the Pacific Climate Workshop (March 2004). Allied to CAP, efforts continued along transects of the Sierra and White Mountains and in the Santa Margarita Ecological Reserve. Instruments placed in 2003 enhanced observations of a record early spring throughout California.

High Resolution Spatial Mapping - K. Redmond (WRCC), A. Gershunov (SIO)

Working with CLIMAS, collaborators continue to address the needs for better spatial mapping including user interfaces, accessibility and education.

Evaluation of WRCC Data Requests - K. Redmond (WRCC), D. Cayan (SIO)

A format is under development for surveying WRCC data users (with California data requests) to learn what information is being sought and how the information could be improved.

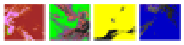
RESEARCH ACCOMPLISHMENTS

- The initial three years of CAP funding found fruition in the fourth year with extraordinary publications, exciting new program development and intriguing observational intake.
- A special issue of *Climatic Change* featured articles from CAP researchers highlighting their work on the Accelerated Climate Prediction Initiative (ACPI):
- N. Knowles and D. Cayan examined the elevational dependence of the projected hydrologic changes in the San Francisco estuary and watershed. Hydrologic modeling revealed that the shift of water in mid elevations of the Sacramento river basin from snowmelt to rainfall runoff is the dominant cause of projected changes in estuarine inflows and salinity.
- T. Brown, B. Hall and A. Westerling investigated changes in wildland fire danger across the western United States due to climatic changed projected in the 21st century. Changes in relative humidity, especially drying over much of the west, are projected to increase the number of days of high fire danger.
- Stewart, D. Cayan and M. Dettinger examined changes in snowmelt runoff timing and found that an already observed early runoff (1948-2000) may occur even earlier (by 30 to 40 days) over much of the western United States.
- M. Dettinger, D. Cayan, M. Meyer and A. Jeton simulated hydrologic responses of the Merced, Carson and American River basins. While earlier streamflow timing was found, long-term average total streamflow and other hydrologic fluxes were found to remain similar to the historical mean.

Several other CAP research efforts were published this year. A new method for frequency analysis of hydrologic time series was developed to facilitate the estimation and reconstruction of individual or groups of frequencies from hydrologic time-series and facilitate the comparison of these isiolated time-series components across data types and watersheds (R. Hanson, M. Newhouse, M. Dettinger, Journal of Hydrology). An article by A. Westerling and T. Swetnam explored interannual to decadal drought and wildfire in the western United States. Soon to be published is an article by H. Hidalgo, D. Cayan and M Dettinger (Journal of Hydrometeorology) showing sources of variability in evapotranspiration in California.

CAP partnership with the California Climate Change Center (CCCC - funded by the California Energy Commission) began this year. This major effort enhances our monitoring efforts and our investigations into topics related to climate change. A special report series was started in the fall of 2003 highlighting CAP/CCCC efforts (see list of reports in Section 10). The California Climate Data Archive was established at the Western Regional Climate Center - Desert Research Institute (DRI). This web-based service provides observational and forecast data over the California region as well as serving a monthly 'California Climate Watch' newsletter.

Painstaking planning and dedication to instrument deployment and retrieval has rewarded CAP with its first glimpse at exciting high-elevation data. Most springs start at low and move to high elevations. However, as published in the *Journal of Hydrometeorology*, the strong influence of short-term weather systems can sometimes overwhelm the effect of elevation and aspect. The spring of 2002 was such a year and the synchronous pulse in streamflow on March 29 was captured by CAP sensors.



EXPERIMENTAL CLIMATE PREDICTION CENTER

John Roads (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The goal of the ECPC is to develop an integrated global to regional climate prediction system by:

- Identifying coupled modes of interannual variability
- Developing models capable of predicting these modes
- Evaluating the predictive capability of these models
- Transferring methodologies to NCEP, IRI, and Regional Application Centers.

APPROACH/EVALUATION AND METHODOLOGY

Persistent surface anomalies in the ocean and land have a strong influence upon atmospheric features that would otherwise be unpredictable beyond a few weeks. We use these persistent anomalies to force experimental state of the art dynamical models initially acquired from national centers (e.g. NCEP) and then further develop these models within the ECPC. We then perform forecast experiments to evaluate the predictive capability of these models. As part of this examination, experimental predictions are made routinely in order to assess the accuracy and usefulness of these forecasts. These experimental predictions are available to the general public graphically via our WWW site and in digital form to interested outside researchers. We subsequently attempt to transfer these models to NCEP, IRI, and Regional Application Centers

RESEARCH ACCOMPLISHMENTS

The ECPC uses the reanalysis I version of the National Centers for Environmental Prediction's (NCEP's) medium range forecast (MRF) model or global spectral model (GSM) along with a corresponding Regional Spectral Model (RSM) to make routine experimental global and regional forecasts on daily (out to 14 days) and weekly (out to 16-weeks) starting from the NCEP operational 00UTC global analysis. Persisted sea surface temperature (SST) anomalies (+climatology) are used as the lower boundary condition.

ECPC's Seasonal Forecast Model (SFM), which is an upgrade to the NCEP/DOE Reanalysis II model, is run differently. Starting from slightly perturbed initial conditions, and forced with observed SST anomalies, 10 simulations are made up to present. Then, persisted SSTs or forecast SSTs are used to generate a 10 member forecast ensemble.

ECPC's SFM is also being used for the international Coordinated Enhanced Observing Period (CEOP). NWP centers have been requested to archive a more complete synoptic gridded output set and there may eventually be corresponding gridded satellite data. ECPC is now recognized as one of the major NWP centers contributing to CEOP.

A fire danger code describing the USFS National Fire Danger Rating System is forced by the RSM and GSM predictions. The fire danger code depends upon past history and must be integrated continuously, using observed precipitation, which we download in near real time from NCEP. These experimental fire danger forecasts are also being displayed at various external sites as an experimental aid in long range planning.

We have begun investigating the NCEP Noah and the Univ. Washington/Princeton Univ. Variable Infiltration Capacity (VIC) land surface models and are coupling these models to the RSM and GSM. We are also working to develop precipitation assimilation in order to develop better land surface assimilations as well as to better couple the land and atmosphere models.

A single column model (SCM), which was previously used to diagnose cloud and radiation profiles over the ARM sites, is now being used to predict detailed characteristics of the atmospheric vertical structure up to a week in advance.

The GSM currently forces a Pacific Basin Ocean Model (OPYC) in order to develop seasonal ocean forecast applications. OPYC is being replaced by the Regional Ocean Modeling System (ROMS), which has the capability to provide higher resolution coastal ocean simulations and forecasts. The SFM is also being coupled to the MIT ocean model and sometime in the future we hope to demonstrate that such a coupled system is better than current persisted or forecast SST's as well as our current ocean forecasts.

Aspects of our experimental ECPC prediction system have already been made available to various application centers, including the International Research Institute (IRI), the California Application Project (CAP), National Taiwan University (NTU), Hong Kong Observatory, and Heilongjiang China Weather Bureau. In addition, the ECPC now provides major support for the regional spectral model, including an RSM model master who maintains the RSM home page and updates the RSM as the parent GSM is updated.

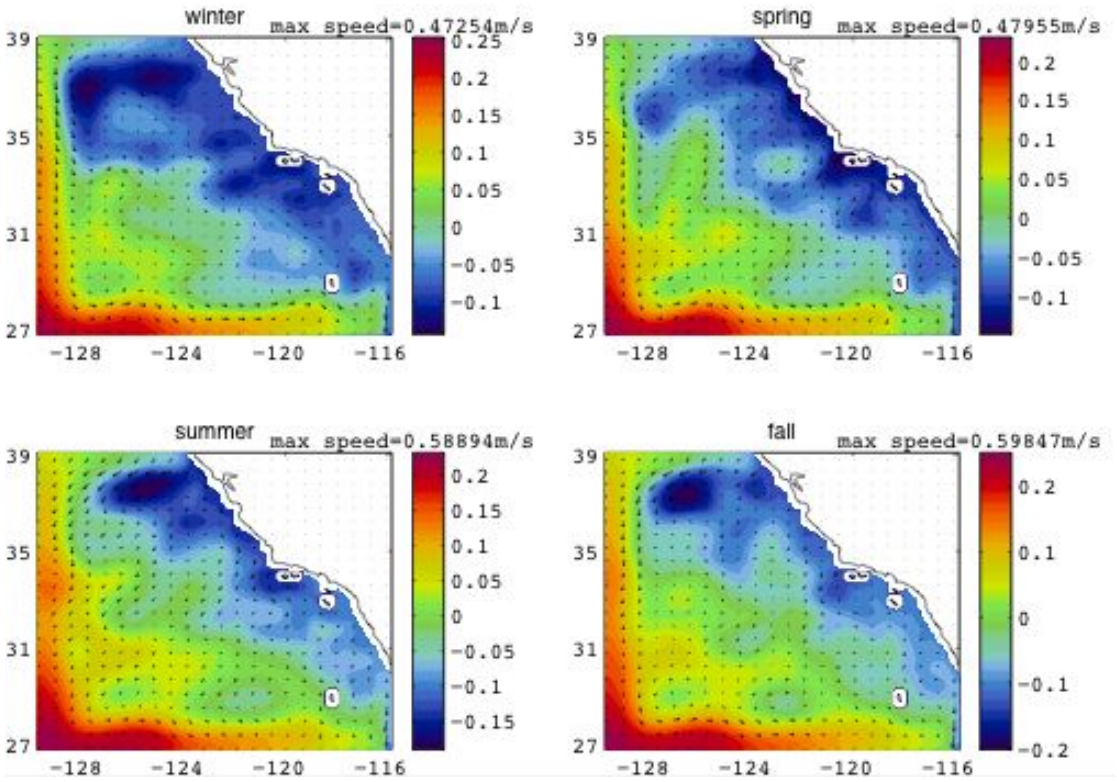


Figure 1. Sea surface height (m) and surface current (m/s) for year of 2003 from ROMS simulations (12km) forced with concurrent 3hourly RSM wind stress, heat flux, and freshwater flux.

DYNAMICAL FORECASTING OF ENSO: A CONTRIBUTION TO THE IRI NETWORK

Mark A. Cane, Dake Chen, and Alexey.Kaplan (LDGO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

To improve our ability to predict ENSO and to make our predictions as usable as possible to the forecasters at application centers. The efforts are focused on forecast system improvements, ENSO predictability, and data assimilation.

APPROACH/EVALUATION AND METHODOLOGY

The project is centered on ENSO forecasting with an intermediate climate model. It involves its further development and uses in operational forecastings. Comparison with observations and studies of model errors (random and biases) are crucial elements. Operational forecasts are produced in coordination with IRI,NCEP, and COLA. Ocean data assimilation activities contributed to the ODASI consortium.

RESEARCH ACCOMPLISHMENTS

This year we have made considerable progress in several research areas. First, we studied ENSO's predictability based on an unprecedented retrospective forecast experiment over the past one and a half centuries. This work was recently published in Nature and reported by press agencies all over the world. Second, we continued to produce monthly ENSO forecasts with the latest version of the LDEO model, and further strengthened our ties with the forecasters at IRI and NCEP. And finally, we made significant contributions to the ODASI consortium by taking part in the OSSE experiment and by studying various issues of data assimilation.

NORTH PACIFIC CLIMATE VARIABILITY AND STELLER SEA LION ECOLOGY: RETROSPECTIVE AND MODELING ANALYSIS

Art J. Miller and Bruce D. Cornuelle (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Around 1976-1977, the Steller Sea Lions (SSL) in the western Aleutian Islands started a decades long decline in population size. This decline occurred at the same time that populations in the eastern Gulf of Alaska (GOA) were stable or slightly increasing in abundance. Many reasons have been proposed for this pattern of decline/stability in the SSL populations including predation, pollution, and loss or change in traditional prey populations. Because the decline was observed to begin after a major shift in the north Pacific climate regime in late 1976, climate change has also been suggested as a cause. Our research explores the possibility of a climate origin to the SSL population trends seen since 1976-1977.

Using The Regional Ocean Modeling System we modeled the circulation in the (GOA) for the period six years before and after the 1976-1977 climate regime shift. Our expectations, if the decline in SSL is climatic in origin, are for changes in the circulation patterns of the GOA which negatively impact the SSL's food chain along the western Aleutians while not affecting the food chains in the eastern GOA.

APPROACH/EVALUATION AND METHODOLOGY

We use the output from an ocean general circulation model (OGCM) driven by observed surface forcing to examine the upper ocean changes that took place in the Gulf of Alaska over the period 1958-1997, including the 1976-77 climate regime shift. In particular, we evaluated the effect on mesoscale eddies in the region which provide a possible mechanism for transporting nutrient-rich open-ocean waters to the productive shelf region. Changes in the intensity of the transport can effect the forage fish populations indirectly by impacting the lower trophic levels that these fish feed on. Subsequently, changes in the size distribution or composition of those fish populations can impact the health of the sea lion populations that feed on them.

RESEARCH ACCOMPLISHMENTS

A distinct change in the ocean circulation of the Gulf of Alaska after the 1976-77-climate shift was observed in our model runs. After the Aleutian Low strengthens, mean velocities of the Alaskan Stream increase northeast of Kodiak Island and decrease southwest of it. Mesoscale eddy variance likewise increases to the northeast of Kodiak and weakens to the southwest. Mean and eddy flows in the eastern Gulf remain unchanged after the shift. Since mesoscale eddies provide a possible mechanism for transporting nutrient-rich open-ocean waters to the productive shelf region, the flow of energy through the food web may have been altered by this physical oceanographic change. This mechanism may explain the changes in forage fish quality in diet diversity of Steller sea lions whose populations have declined precipitously since the mid-1970's in the western Gulf while remaining stable in the eastern Gulf.

In addition, we use the output from an ocean general circulation model (OGCM) driven by observed surface forcing to examine the upper ocean changes that took place in the Gulf of Alaska over the period 1958-1997, including the 1976-77 climate regime shift. The pycnocline deepened after the mid-seventies in a broad band along the coast, and shoaled in the central part of the Gulf of Alaska. The changes in pycnocline depth diagnosed from the model are in agreement with the pycnocline depth changes observed at two ocean stations in different areas of the Gulf of Alaska. Using a simple Ekman pumping model with linear damping we found that a large fraction of pycnocline variability in the OGCM can be explained by local Ekman pumping. The fit of the simple model to the OGCM is maximized in the central part of the Gulf of Alaska, where the pycnocline variability produced by the simple model can account for ~70-90% of the pycnocline depth variance in the OGCM. The agreement between simple model and OGCM deteriorates in a large band along the coast, where the propagation of disturbances within the pycnocline appears to play an important role in pycnocline variability. Propagation of pycnocline depth anomalies is especially relevant in the western part of the Gulf of Alaska, where local Ekman pumping changes would lead to pycnocline variations of the opposite sign than those in the OGCM. The inclusion of a propagation term in the simple Ekman pumping model considerably improves the agreement with the OGCM along the coast.

NCEP ENSEMBLE SEASONAL FORECAST VERIFICATION AND APPLICATION PROJECT: A CONTRIBUTION TO THE ARCS/IRI NETWORK

John Roads (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The original goal of the project was to diagnose the skill of the current operational NCEP seasonal forecast model (SFM). We approached the goal from different directions. We started to archive NCEP SFM forecasts every day for the past last year and created a large data archive. The other approach was to produce forecasts following the guidelines provided by IRI. This effort was already started because of the predictability efforts begun under the previous consortium effort. In fact while the predictability experiments were underway several improvements were made to the ECPC version of the NCEP SFM and these improvements could eventually lead to a better seasonal forecast model at NCEP. We also began to contribute these seasonal forecasts to the Seasonal Climate Diagnostics Consortium at CPC as well as to the IRI multi-model ensemble on a routine basis.

APPROACH/EVALUATION AND METHODOLOGY

The ECPC seasonal forecast model (SFM) originated from the global spectral model with a resolution of T62L28 (about 200km) used operationally at NCEP for routine seasonal prediction and as the basis for the NCEP/DOE reanalysis II. This resolution is

good enough for representation of transient disturbances in extra-tropics and is also capable of simulating strong tropical cyclones. The model uses a reduced grid strategy to save running time by 20-30 %. The model physics includes long and short wave radiation, cloud interaction, convection, large-scale heating, shallow convection, boundary layer physics, gravity wave drag and hydrology. The model has been extensively tested for seasonal prediction, and is now running operationally at NCEP. At ECPC, the model has been further updated to improve predictions over semi-arid regions. This was done by using better land-surface characteristics and a different formulation of evaporation from soil. The model's hydrology has recently been examined intensively for budget studies, and was revised to strictly conserve water (and snow) in the model integration. This will have a significant impact on soil moisture simulation in the long integrations. The model also has the capability to test various new physical packages (already coded), and we plan to examine them systematically from the seasonal forecast output. A number of small improvements were made to the original global SFM. These improvements included change to the basic land surface data sets (vegetation type, vegetation cover, soil type) from USGS, and associated change in surface roughness parameter and albedo, and formulation of the direct evaporation from soil. One 20-year AMIP run was run with these improvements and was compared with the original SFM. The improvements in the simulation were found to be small compared to shorter RSM simulations, probably due to the non-linear effect of the land surface on general circulation.

In the last several months, the GSM has been upgraded to include several new and powerful features including: 1) the complete merge of GSM and the corresponding regional spectral model (RSM), now makes the implementation of the physics packages transparent to both models; 2) improvement of land surface package interface to make the implementation of a new land surface programs much easier; 3) implementation of NCEP's latest NOAH land surface parameterization (LSP), with an assistance of Dr. Sarah Lu from NCEP; and 4) the soon to be completed implementation of a simplified VIC LSP. We are currently examining the performance of the new LSP schemes in seasonal forecast setting, and will hopefully be augmenting the current operational scheme (OSU) with the Noah and/or VIC by the end of May 2004.

RESEARCH ACCOMPLISHMENTS

Ensemble Seasonal Forecasts

ECPC seasonal forecasts are available within approximately 3 days from the time the SSTs are received. Results from the forecast are posted on the ECPC web site (http://ecpc.ucsd.edu/projects/GSM_model.html). Two new land schemes, Noah and VIC, are being implemented and tested. The Noah scheme has been thoroughly tested with 10-member 50-year runs with observed SST. Preliminary evaluation shows that the model climatology and simulation skills are as good as those of the current Oregon State University scheme. The results of the Noah runs have now been sent to IRI for their examination. We expect that the monthly seasonal forecast model will be replaced with the Noah version by August 2004.

Tropical Predictability

Forecasting tropical variations is not only complicated by the lack of good observations, but also by the relative complexity of tropical dynamics, which are governed by fundamentally different principles than the extratropics. We were interested to find out at what time scale the tropical atmosphere responds to changes in the underlying forcing, and how sensitive tropical forecasts are to uncertainties in the description of the underlying ocean. Our studies of tropical predictability examined two different time scales: First, monthly means were investigated, which cover intraseasonal to interannual time ranges. Second, 30-60 days filtered data were examined to capture the predictability of the Madden-Julian Oscillation (MJO) phenomenon.

Relation Between Long Term Trend of Predictive Kill and SST Variance

Nakaegawa and Kanamitsu linked seasonal forecast skill with the temporal variability of the tropical SST. It was shown that the temporal variance of the tropical SST has increasing trend, which corresponds well with the increase in forecast skill. The increasing variance is also examined in various observed and simulated parameters, which showed similar trends in some of the parameters but not all. One implication of this study is that we need to be cautious about forecast skill and AMIP-type run simulation in very early years (late 1800 to early 1900) when SST observations were sparse.

Study of Ensemble Variance

Nakaegawa and Kanamitsu found the 10-member ensemble could be easily expanded to 40-member ensemble by aggregating the forecasts from prior months. Using the 40-member ensemble, it was shown that PDF between ENSO and non-ENSO years could be clearly differentiated.

Use of Cluster Analysis to Improve the Forecast

The merit of the cluster analysis is that one pattern can be separated into multiple patterns through hierarchical analysis. By this method, typical PNA patterns, for example, can be further separated into two or more patterns, which may help to explain why the

PNA patterns varies for similar tropical forcing. The second part of the study examined the clusters within a single ensemble forecast. Cluster mean anomalies (ACCs) were computed for each cluster at each level of the hierarchy and then anomaly correlation between cluster mean anomalies and observed anomalies are calculated. The highest ACCs in all clusters at all levels were always higher than ACCs of the ensemble mean from all of the selected clusters.

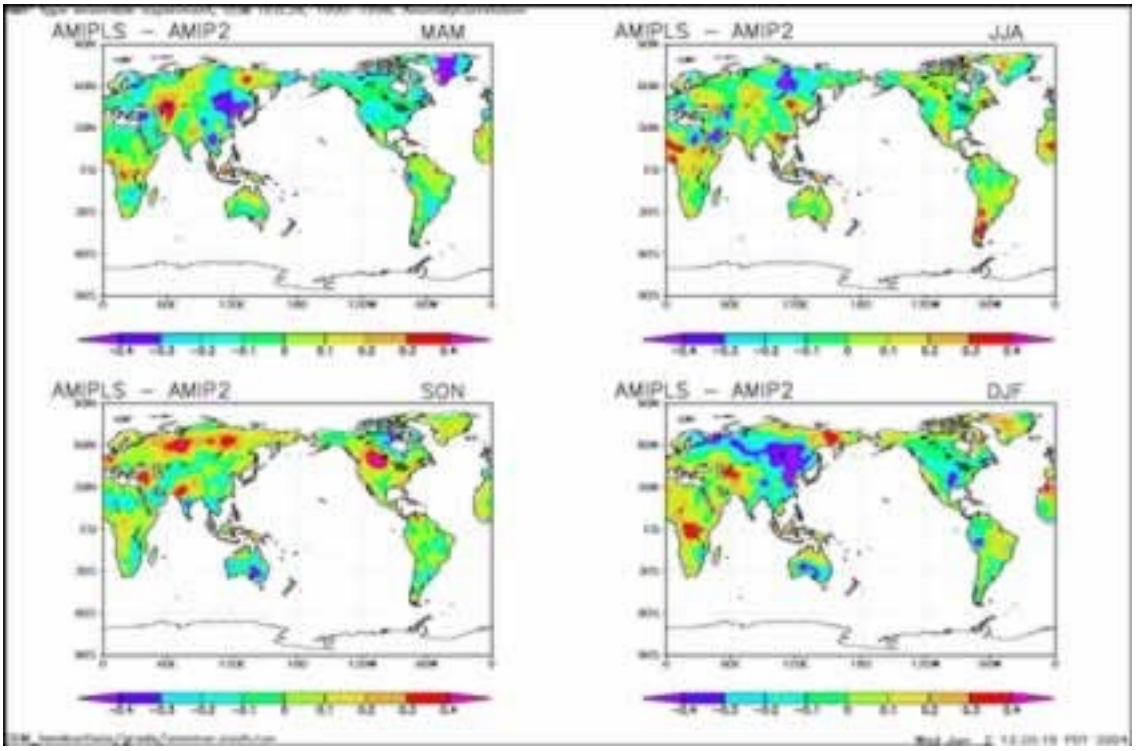


Figure 1. Comparison of 2-meter temperature skill for 4 seasons between Noah and OSU (Noah minus OSU) computed from 10-member 50-year AMIP type runs. Observations are provided by IRI.

PROJECT ASIAN BROWN CLOUD: REGIONAL AEROSOL-CHEMISTRY-CLIMATE OBSERVATORIES FOR THE INDO-ASIA-PACIFIC REGION

Veerabhadran Ramanathan (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Project Atmospheric Brown Cloud (ABC) was initiated by the United Nations Environment Programme (UNEP) with financial support for the US aerosol component from NOAA, and participating member nations for respective programs. ABC scientists plan to establish a network of ground based monitoring stations throughout the Indo-Asian and Pacific regions to study the composition and seasonal patterns of brown clouds.

The main goals for the ABC observatories are 1) to document changes in aerosol contents, optical depth, chemical composition, aerosol radiative forcing and cloud properties, and 2) do document changes in pollutant gases and some greenhouse gases. Along with satellite data and periodic aircraft measurements, the observations will provide critical inputs for models and will enhance their predictive capability.

The aim of the first phase of ABC program is to study the impact of atmospheric brown clouds on a number of parameters, including radiative forcing, monsoon change, water balance, agriculture and health.

APPROACH/EVALUATION AND METHODOLOGY

The primary focus of this proposal is the characterization of the regional distribution of black and organic carbon aerosols, single scattering albedo and raditative forcing and the assessment of the contribution of Indo-Asian-Pacific region to global aerosol forcing. Specifically, the NOAA funds will be used to contribute to the following objectives:

- Establish continuous chemical and microphysical aerosol observations and radiometric observations at key locations in the Indo-Asian-Pacific region with a particular emphasis on organic and black carbon aerosols and dust.
- Determined short-wave and long-wave aerosol radiative forcing at the surface and top of the atmosphere directly from radiometric observations at the observatories and integrate these with satellite data and regional assimilation models to produce regional estimates.
- Relate the aerosol forcing to regional sources of aerosol emissions based on analysis of molecular markers in aerosol filter samples, aerosol single particle analyses and regional aerosol assimilation models.

RESEARCH ACCOMPLISHMENTS

Aerosol Radiative Forcing. Data from surface measurements at the Himalayan foothills during winter of 2002 and from NASA-Terra MODIS satellite revealed an extensive layer of aerosols covering the entire region with seasonal mean AODs of 0.3 -0.5 in the visible wavelengths which is among the largest seasonal mean dry-season AODs for the tropics. The aerosols in the brown clouds lead to an increase in solar absorption of about 25 Wm-2, equivalent to an increase in solar heating rate as large as 1 K/day between the surface and 2 km, exceeding those estimated for other regions of the world (Figure 1).

Asian Dust Distributions. Seasonal variations of two major Asia dust plumes were explored with satellite data, NOAA PathFinder (horizontal expansion), SAGE II (vertical profiles) and Terra MODIS (effective radius distributions.) Asian dust explosions persist during March-May spreading toward North America. Seasonal variation of the dust aerosol effective radius displays a negative correlation with AOD fluctuation suggesting local small particle pollutants merging in during transport. Quantification of those features will be a key component in ABC climate effects.

Aerosol Radiative Forcing. To derive a global seasonally varying aerosol forcing estimate, a global dataset was generated for total AOD, its SSA, its asymmetry parameter and the anthropogenic fraction. This dataset was generated by integrating GOCART (Georgia Tech/Goddard Global Ozone Chemistry Aerosol Radiation Transport) simulated aerosol products, MODIS AODs and AERONET observations. The C4's MACR (Monte-Carlo Aerosol-Cloud Radiation) was updated to account for the surface orography and to include the spatial-temporally varying ozone and water vapor observations. The cloud climatology was processed using the ISCCP D2 products. This global radiation model is being used to derive the global aerosol forcing with the integrated AODs/SSAs.

Climate Modeling Studies. Multiple ensemble runs were conducted on the NCAR's PCM (Parallel Climate Model) including the haze forcing with values during summertime derived from the GOCART model simulated AODs; the forcing outside of summer. This new experiment simulates the observed drying trend of the Indian summer monsoon. The mechanism for the drying trend is through the cooling of the ocean surface in the northern Indian while the southern Indian is intact.

Climate Forecasting. A major goal of ABC observations is to understand the linkage between the sources of aerosols and the resulting radiative forcing. Models will be used to provide realistic estimates of the spatial and temporal distributions of aerosol optical and chemistry information as well as to assess the relative importance of emission from combustion of coal, diesel and fossil fuel on the observed absorbing aerosols. The STEM-2K1 regional model is being used for the ABC study. Specifically, October 2003 has been simulated for the Indian Ocean region as a conceptual evaluation for ABC applications (Figure 2). The model will be run in a real time forecast mode during the ABC intensive campaign in October 2004.

Instruments for Ground Observations. Massive efforts have been directed toward procuring and setting up top of the line solar radiation and aerosol instruments for the first group of ABC surface observatories to be established in countries that have had agreement with ABC including Bangladesh, India, Korea, Maldives, Nepal, Sri Lanka and Thailand. As part of initial quality control and assessment, a prototype PM2.5 sampler was deployed for a month at Trinidad Head during March-April 04 for EC/OC and mass measurement. This sampler is now deployed in the Maldives. Another aerosol mass sampler is now part of ABC observatory in Midway, operating since July 04.

Average Component Contribution to AOD

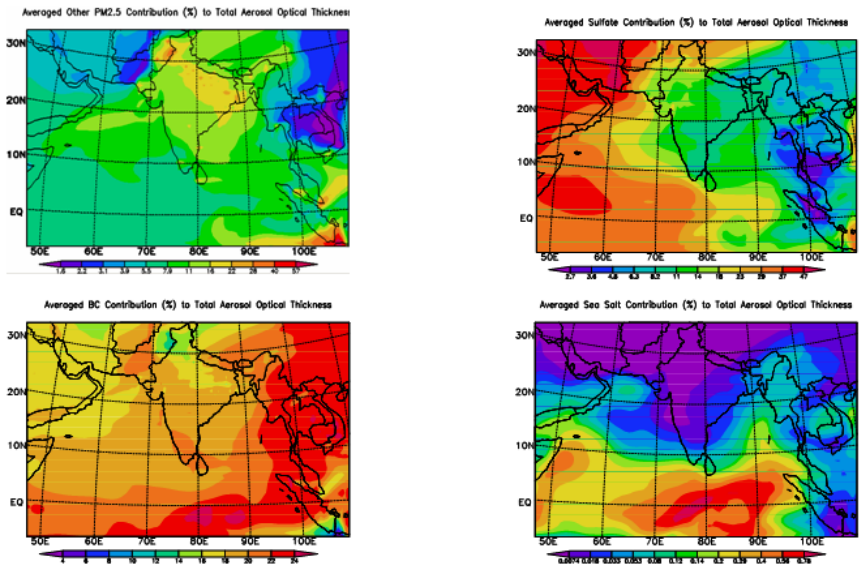


Figure 1. Reduction in global radiation reaching the Earth's surface: Percentage reduction of top of the Atmospheric (TOA) insolation per unit optical depth (at 500nm) at the surface for different parts of the globe. Diurnal clear sky Radiative Forcing Efficiency normalized with diurnal averaged TOA solar insolation and converted into percent of TOA insolation.

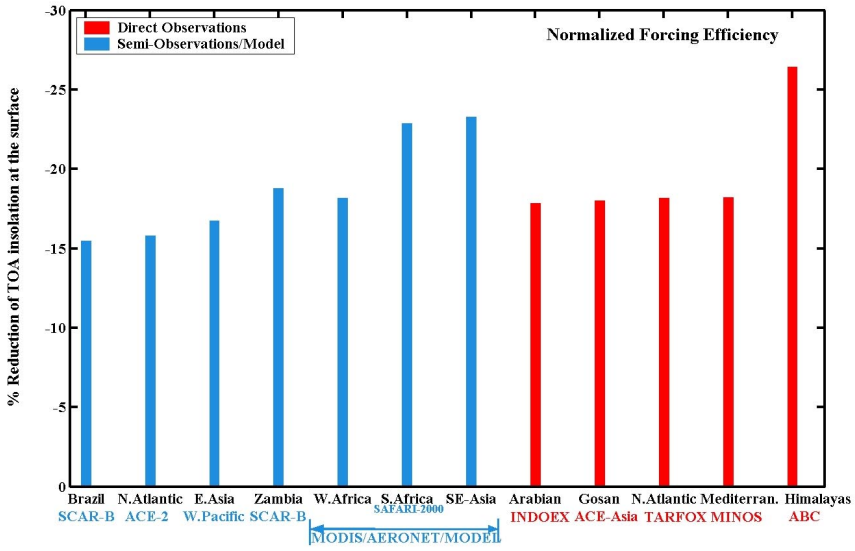


Figure 2. Estimated contributions to aerosol optical depth (AOD) by major aerosol types estimated using the STEM-2K1 regional model for October 2003. The model will be run in a real time forecast mode during the ABC intensive campaign in October 2004 (Courtesy of G. Carmichael, U. of Iowa).

FORECASTING CLIMATE CHANGES OVER NORTH AMERICA FROM PREDICTIONS OF OCEAN MIXED LAYER ANOMALIES IN THE TROPICAL AND MID-LATITUDE PACIFIC

Niklas Schneider (International Pacific Research Center, School of Ocean and Earth Science and Technology)

Link to NOAA Strategic Plan:
NOAA's Mission 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Our research explores the underlying physics and skill of a two-tiered prediction system for climate anomalies over North America for lead times of seasons to years. In contrast to the traditional approach that forecasts anomalies of SST, the first tier of this system predicts anomalies of the oceanic heat flux convergences in areas where the surface ocean is impacted by predictable subsurface variability, namely in the tropics and in the Kuroshio-Oyashio extension (KOE) region . The second tier forecasts associated anomalies of the global atmosphere and, in particular, of climate over North America by forcing a coupled atmospheric general circulation/slab ocean model (AGCM/SOM) with surface heat budget anomalies obtained during the first phase.

In order to achieve these objectives we performed the following numerical experiments:

- Determined anomalous ocean heat flux convergence over the Kuroshio Extension and equatorial Pacific regions by diagnosing the air-sea heat flux of the MIT 1°x1° ocean model forced with NCAR/NCEP reanalysis wind stress anomalies, while relaxing SST to climatology.
- Forced the coupled AGCM-slab ocean model (CCM3/SOM) with the heat flux convergence anomalies. Run 5-member ensemble integrations from January 1960 to December 1999, with the forcing in (A) both KOE and tropical Pacific regions, and (B) in the tropical Pacific only.

In addition, our research clarified the forcing of the Pacific Decadal Oscillation (PDO). The Pacific Decadal Oscillation is the leading mode of variability of sea surface temperature in the North Pacific. It is a widely used index for Pacific Decadal variability and co-varies with North American and East Asian climate, the North Pacific Ecosystem, and with modulations of tropical Pacific to North American teleconnections.

APPROACH/EVALUATION AND METHODOLOGY

The output from the second tier of the prediction system was analyzed by performing multivariate regression onto two heat flux convergence indices: (1) oceanic heat flux convergence averaged over the KOE region and (2) oceanic heat flux convergence averaged over the NINO3.4 region. The corresponding regression maps showed the coupled system response to the forcing in different regions. The comparison with the model (B) revealed the non-linear effect of the mid-latitude forcing. The daily model output was analyzed and the role of the transient eddies in maintaining the response patterns was investigated.

In order to clarify the physical mechanism that excites and maintain PDO, a first order auto-regressive model for July to June annual averages of sea surface temperature in the North Pacific was constructed. The July to June annual averages of sea surface temperature in the North Pacific were fit to a first order auto-regressive model and forcing indices of El Nino, anomalies of the strength and position of the Aleutian Low, and ocean thermocline and zonal flow anomalies in the Kuroshio Extension region in the Western North Pacific.

RESEARCH ACCOMPLISHMENTS

- The hindcast experiments with the two–tiered prediction system revealed that the low frequency ocean heat flux convergences in the Kuroshio extension region influence the climate over the North Pacific and North America.
- The response includes the response in the mean flow as well as the modulations of the Pacific Storm track and eddy dynamics. Transient eddies play significant role in the resulting spatial patterns.
- Downstream of the forcing eddy effect counteracts the linear baroclinic response to the diabatic heating.
- Model shows a significant effect of the mid-latitude forcing to the temperature and precipitation variability over Alaska and Pacific Northwest.

- The predictable low-frequency ocean heat flux convergences account for 27% of the variance of the low-frequency 2m temperature anomalies over these regions. The difference between the probability distribution functions for the 2 m temperature averaged over west coast of Alaska corresponding to the positive and negative phases of the mid-latitude forcing revealed a shift in both mean values and in extreme events (Figure 1).

The findings from the second part of our research can be summarized as follows:

PDO can be reconstructed to a high degree of accuracy from its own history, and indices of El Nino, of intrinsic variability of the Aleutian Low, and of ocean gyre anomalies in the Kuroshio Extension.

El Nino impacts the North Pacific in well-known patterns teleconnection patterns with warm conditions in the eastern North Pacific along the North American coast and in the Alaska gyre, and cool condition in the Central North Pacific.

The footprint of a deepened Aleutian Low on SST is similar in the east, but extends further west with large cooling along the frontal zones at 40N. Eastward zonal flow anomalies in the Kuroshio extension lead to warm anomalies. The damping time scale of temperatures in the North Pacific is typically just shy of one year, with little significant spatial variations.

The leading mode of the reconstructed SST anomalies capture the time evolution and spatial pattern of the PDO, with correlation in space and time in excess of 0.9. This allows the evolution equation of the PDO to be derived, and shows that it too is dependent only its own history, and the forcing indices - the coupling of the PDO to other modes of North Pacific variability of SST is small.

The contribution of the different mechanisms is frequency dependent (Figure 2). At annual and shorter time-scales by the Aleutian Low dominates, at interannual time-scales teleconnections from the tropics, intrinsic variations of the Aleutian Low are of equal importance. The influence of gyre anomalies in the Kuroshio extension is small for annual time scales, but at decadal time scales the ocean gyre contribution is on par with the other two forcings.

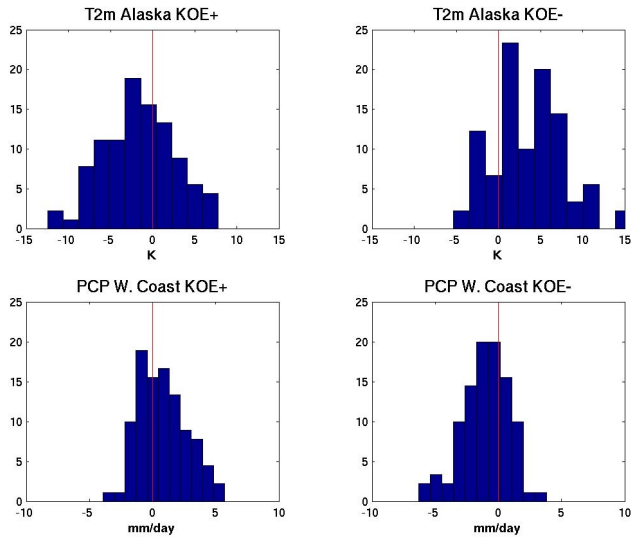


Figure 1. Difference between the Probability Distribution Functions for positive and negative KOE forcing phases. 2m Temperature (upper line) and Precipitation (lower line) averaged over the regions with statistical significant difference of the response.

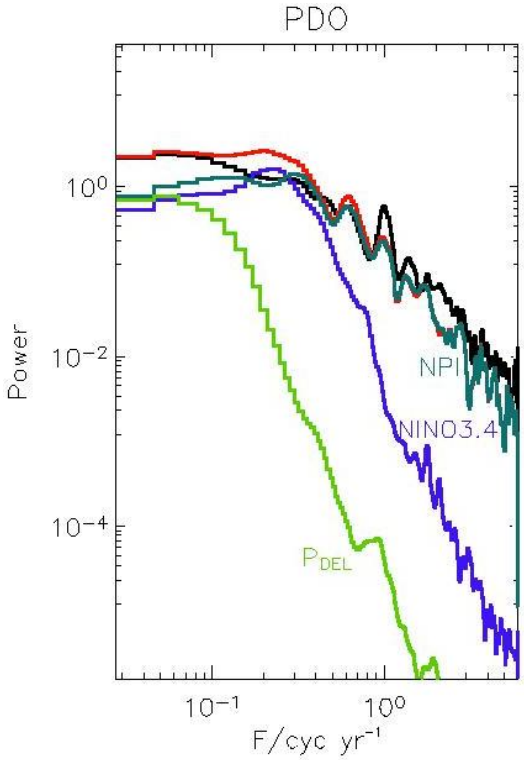


Figure 2. Power spectrum of the PDO and its contributions, as a function frequency in cycles/year. Shown are the spectra of the PDO (black), and the contributions due to anomalies in depth and position of the Aleutian Low (magenta), due to El Nino (blue) and due to zonal advection in the Kuroshio Extension (green). The sum of the contribution is shown in red, and slightly overestimates the observations at interannual time scales since changes of the Aleutian Low and ENSO share some variance.

US GLOBAL WATER AND ENERGY BUDGET STUDIES: A CONTRIBUTION TO CEOP

John Roads (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The Coordinated Enhanced Observing Period (CEOP) provides a new forum to access output from model and satellite products, as well as in situ observations on diurnal time scales. Our goal is to provide ECPC global model output and to compare this output with available observations in order to determine how well we can simulate the surface and atmospheric diurnal water and energy cycles.

APPROACH/EVALUATION AND METHODOLOGY

Develop, provide, and analyze NCEP/DOE Reanalysis II model and ECPC seasonal forecast/analysis model output for CEOP period (July 1, 2001-December 31, 2004). The model output contains all the 3-dimensional water and energy budget processes.

RESEARCH ACCOMPLISHMENTS

Using the Tropical Rainfall Measuring Mission (TRMM) satellite's precipitation record as well as CEOP station gauge data, we have tested the models' ability to reproduce the global water and energy diurnal cycles. By separating individual components of the water and energy balances, we can identify variables that dominate the local balances in the models and note regions of similar characteristics). In general, the relative magnitude and phase of each variable's least-squares-fit diurnal harmonic adjusts seasonally, in qualitative accordance with CEOP and TRMM observations, although there are certain times, especially over mid-latitude summer regions, where the precipitation diurnal phase errors are large. Using CEOP in situ observations, we can show that some of the diurnal precipitation phase error can be attributed to diurnal evaporation errors. There are obviously other possible contributions to the phase errors. In addition to exploring the roles of different geographic influences over the continents, we have also found a strong land-sea contrast in phase and relative amplitude that appears in our models. This contrast may be overly influenced by the fixed sea surface temperature variations used to force the model, which suggests that coupled ocean-atmosphere models as well as oceanic observations may eventually be needed to fully explain land-sea geographic variations in the diurnal cycle.

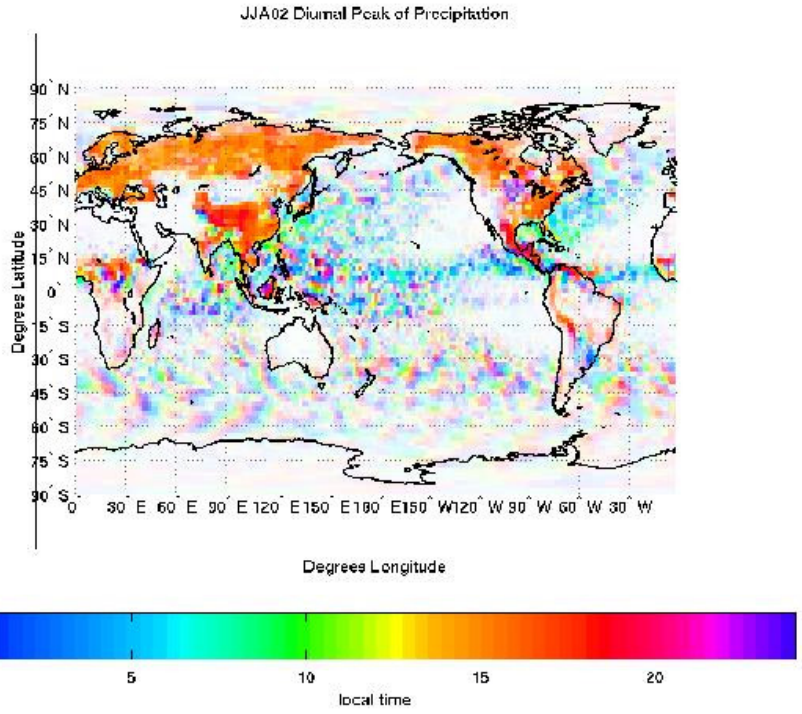
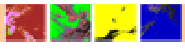


Figure 1. Local time and amplitude of peak precipitation according to least-squares-fit diurnal harmonic from the Seasonal Forecast Model over JJA 2002. The colors indicate time of day, while the intensity indicates the amplitude.



EVOLUTION OF ENSO AND TROPICAL PACIFIC CLIMATE

Christopher Charles (SIO)

Link to NOAA Strategic Plan:

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Developed a quasi-continuous, comprehensive reconstruction of the El Niño phenomenon over the last millennium by using the climate record of fossil corals. Our strategy is to analyze an existing collection of fossil coral records from Palmyra Island (central

tropical Pacific), whose ages span the last 1200 years. Though any one individual coral record is only 50-100 years in duration, the records may be spliced together to create an extended time series, with approximately monthly resolution. Our work also sought to replicate (or simply test the reproducibility of) the Palmyra reconstruction by collecting analogous observations from other coral atolls in the central Pacific, including Christmas Island (2°N) and Fanning Island (4°N).

Once in place, and the uncertainties in the reconstruction quantified, we can characterize the evolution of ENSO with unprecedented detail.

APPROACH/EVALUATION AND METHODOLOGY

In this first year of the project, we continued to analyze the stable isotopic composition of the fossil corals that we had already collected from Palmyra Island. We focused on splicing records from the 13th century and generating an extended record from the 11th century. We confirmed the reproducibility of the analyses in multiple corals. This work entailed approximately 3500 individual stable isotope measurements.

We also planned a field excursion to Christmas Island to collect fossil coral cores that would substantiate and/or fill in the gaps of the Palmyra collection. This trip had to be postponed twice, for different reasons entirely out of our control, but we are now scheduled to complete this sampling expedition on August 23rd, 2004.

RESEARCH ACCOMPLISHMENTS

As a result of our continued laboratory work in this first year, we are very close to creating a continuous time series of the ENSO phenomenon, that extends from 1050-1500 AD, at monthly resolution. This extended record complements other previously analyzed windows available from the 17th century and 19th and 20th centuries. We have also successfully demonstrated the reproducibility of the coral splicing approach, at least at one important location.

In total, the analysis thus far shows a clear "regime-like" behavior of ENSO. This non-stationarity is evident throughout the record, and the characteristics of ENSO thus far show little correlation with other indicators of global climate.

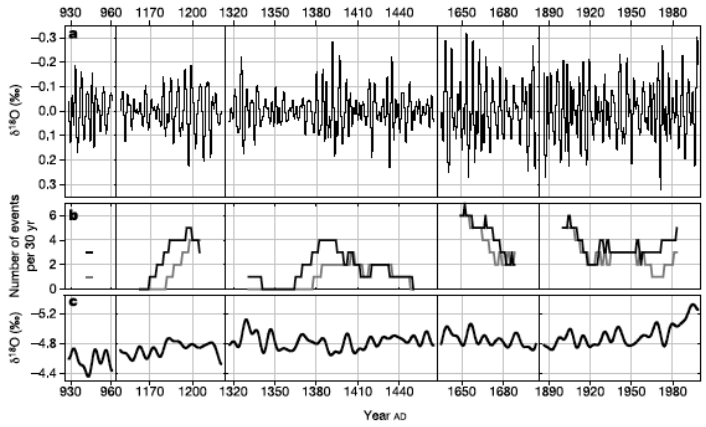


Figure 6 ENSO and lower-frequency components of the Palmyra coral $\delta^{18}O$ records. **a**, ENSO variability isolated by applying a 2–7-yr bandpass filter to the deseasoned monthly coral $\delta^{18}O$ anomaly data, plotted contiguously. **b**, An index of ENSO activity, defined as the number of El Niño (black) and La Niña (grey) events in a sliding 30-yr window. An El Niño (La Niña) event is defined by annual-mean $\delta^{18}O$ anomalies (computed from the 2–7-yr bandpass filter series, centred on January) that are less than (greater than) −0.11‰ (+0.11‰). This threshold corresponds to one standard deviation of the modern coral's 2–7-yr bandpassed record, and is roughly equivalent to NIÑO3.4 SST anomalies of 0.6°C, according to the calibration presented in Fig. 2. **c**, Lower-frequency climate variability isolated by applying an 8-yr lowpass filter to the coral $\delta^{18}O$ data.

Figure 1. Taken from Cobb et al., Nature, 424, pp. 271-276.

GLOBAL MODEL INVESTIGATION OF WARM SEASON PRECIPITATION FOR NORTH AMERICAN MONSOON EXPERIMENT

Guang Zhang (SIO)

Link to NOAA Strategic Plan:

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

- Simulate the seasonal evolution of the North American monsoon system using a global climate model.
- Simulate the diurnal cycle of convection and understand its relationship to seasonally varying mean climate.

The National Center for Atmospheric Research Community Atmospheric Model was used together with a developed and improved convection parameterization scheme to improve the simulation of the diurnal cycle of convection over the North American Monsoon region.

APPROACH/EVALUATION AND METHODOLOGY

The project focuses on the modeling component of the North American Monsoon Experiment (NAME). Through carefully designed numerical experiments, multi-year CCM3 simulations were performed to composite the diurnal cycle of convection and associated dynamic and thermodynamic conditions. The composite structure of circulation, precipitation and hydrological cycle are compared with observational results to determine systematic differences between model and observations.

RESEARCH ACCOMPLISHMENTS

Significant progress was made in understanding the ability of global climate models in simulating the various aspects of the warm season precipitation in association with the North American Monsoon system. Multi-year model integrations were carried out using the NCAR CCM3, with observed sea surface temperature as the lower boundary condition. One uses the standard CCM3, and the other uses the new convection parameterization closure recently developed by Zhang. Each set is equivalent to an ensemble simulation of the summer monsoon season climate. Our objective is to examine the diurnal cycle of convection and precipitation in the North American Monsoon region and its sensitivity to convective parameterization. From the observational studies, precipitation in the southern Great Plains reaches maximum in the months of May and June. As the North American monsoon develops in the southwestern states and Mexico starting in July, precipitation in the Great Plains starts to decrease. However, this is not well simulated in the standard NCAR model, as is evident in the month-to-month evolution of precipitation in Figure 1. Furthermore, the mean precipitation is excessive. The maximum convection occurs around 3 to 4 pm in the afternoon (GMT is 6 hours earlier than LST), which is much earlier than the observed time of evening to midnight. This could have an important impact on the atmospheric energy budget, as cloud systems during the day would have a large shortwave radiative forcing. In contrast, in the simulation with the new convection scheme, we are able to get the maximum convection to occur at night, again in better agreement with the observations.

The diurnal cycle of convection over the contiguous U.S. was examined (Figure 2). Convection occurs in early to mid-afternoon almost everywhere in the continent in the standard CCM3 simulation. This has little resemblance to observations. In the simulation with the new convection scheme, the diurnal cycle is improved in most of the places, except in the southeast, where the observations show large amplitude with maximum in the later afternoon. The regime shift east of the Rockies is clear in the simulation, as is in the observations.

In addition to the NCAR CCM3 simulations, active participation in the inter-model comparison project, involving our NCAR model, GFDL model and NASA model. Through a number of conference calls with participants from NASA, GFDL, NCEP and SIO, there was exchange of data information and preliminary results. This was proven very beneficial to the community in understanding the capabilities of the global model in simulating the North American Monsoon system.

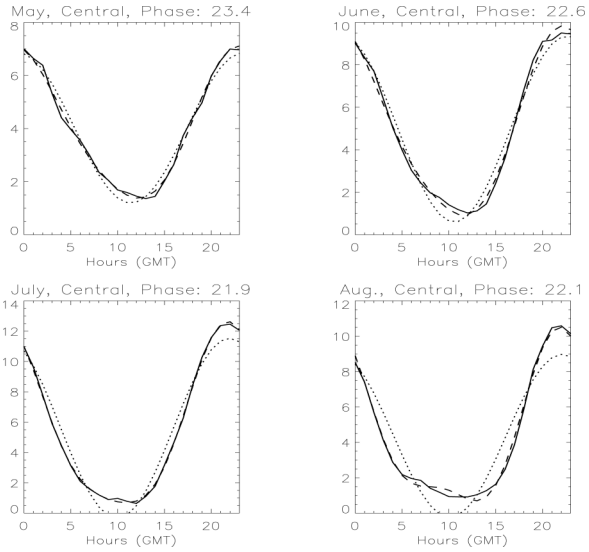


Figure 1. Composite diurnal cycle of convective precipitation (in mm/day) from CCM3 for the warm season, averaged over the box (92.5W, 97.5W), (38N, 42N) in the U. S. Central/Southern Great Plains. Solid line is the actual composite, dotted line is the diurnal harmonic fit, and dashed line is the diurnal plus semi-diurnal fit. The phase value at the upper-right corner of each frame is the time (in GMT) at which maximum convection occurs using diurnal harmonic fitting.

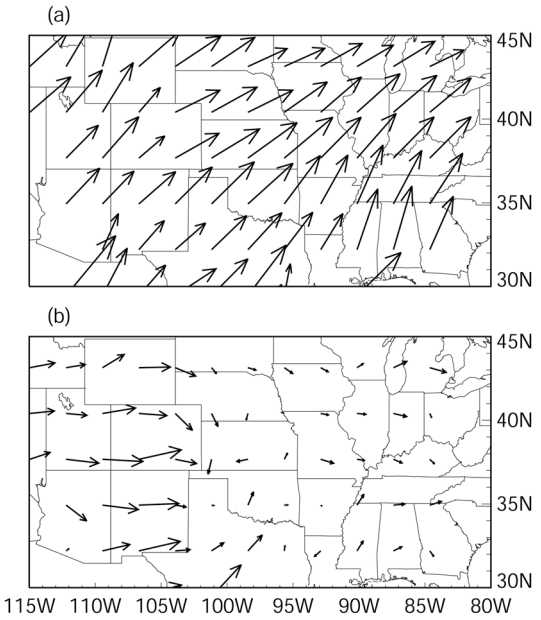


Figure 2. Dial vector of diurnal cycle of convective precipitation in JJA from (a) standard CCM3, and (b) same except with the new convective parameterization closure. A vector pointing downward means the maximum convection occurs at 0000 LST, pointing to the left means the maximum occurs at 0600 LST, and pointing upward means the maximum occurs at 1200 LST.

IRI/ARCS REGIONAL MODELING

John Roads (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The objective of this research is to develop regional applications of seasonal forecasts using regional climate models. At the ECPC this research will make use of the enhanced CVS version of the RSM developed to closely emulate the new Seasonal Forecast Model and this model was used for global change experiments. New physics are being developed for the global and regional models including angular momentum and moisture mixing. The surface vegetation is being changed to a heterogeneous type with 13 kinds. The gravity wave drag will have multi-direction effects depending on wind direction. Finally, the parallelization of the Regional Spectral Model is now complete and will provide increased capability for developing long-term simulations.

APPROACH/EVALUATION AND METHODOLOGY

Specific research objectives include:

- Incorporation of new land surface parameterizations in the RSM (Noah and VIC)
- Precipitation Assimilation to enhance downscaling regional climate simulations
- Application of RSM to fire danger forecasts

RESEARCH ACCOMPLISHMENTS

Land Surface Parameterization

Chen and Roads examined RSM simulations over Brazil. It was found that there was a drying trend in the RSM soil moisture, which was a response to the positive feedback between the imperfect cumulus parameterization scheme and the soil moisture module in the model. The drying trend could be prevented by tempering the soil moisture in the model during the integration. Anomaly threat scores and biases did show added skill (better than reanalysis) at extreme precipitation threats.

In addition to attempting to now include precipitation assimilation, we are also attempting to improve the land surface parameterization. In particular, we would like to understand potential feedbacks of the land surface upon climatic features and then begin the research needed to make long-range predictions of various hydroclimatological variables like soil moisture, stream flow, snow, as well as surface temperature and precipitation. We have now added the NCEP Noah and the Univ. Washington/Princeton Univ. VIC (Variable Infiltration Capacity) land surface models as CVS options.

Precipitation Assimilation and Regional Model Intercomparisons

A multi-year simulation inter-comparison project involving the ECPC-RSM with and without PI (control experiment) is being prepared for the PIRCS (1c). The PIRCS experiment 1c will be a 13-year simulation with 6 months as spin-up (1986 July 1 to 1999 December 31). The NCEP-DOE Reanalysis-2 (R-2) and Reynolds's SST (1-degree resolution) are being used as forcing data. The experiment al domain covers 145 W-55W and 5N-60N. We have already participated in two previous PIRCS experiments, which have shown that our RSM is one of the best regional models. The PIRCS experiment will be used as the control run for our other RSM experiments with precipitation assimilation and investigations of land surface forcing over the US. Plans for additional intercomparison experiments are also being developed in conjunction with several national and international organizations.

Fire Danger

We developed an experimental US fire danger prediction system using the Regional Spectral Model (RSM) and the National Fire Danger Rating System described above. All of the NFDRS indices can be predicted well at weekly times scales and there is even skill out to seasonal time scales over many US West locations. The most persistent indices (BI and ER) tend to have the greatest seasonal forecast skill. The NFDRS indices also have a weak relation to observed fire characteristics such as fire counts (CN) and acres burned (AC), especially when the validation fire danger indices are used.

Further assessment of our RSM predictions in comparison to western US Remote Automated Weather Station (RAWS) observations was published by Reinhold et al. Of the atmospheric elements, temperature generally correlated well, but relative

humidity, precipitation, and wind speed were less well correlated. Fire danger indices had much lower correlations, but did show useful spatial structure in some areas such as Southern California, Arizona, and Nevada.

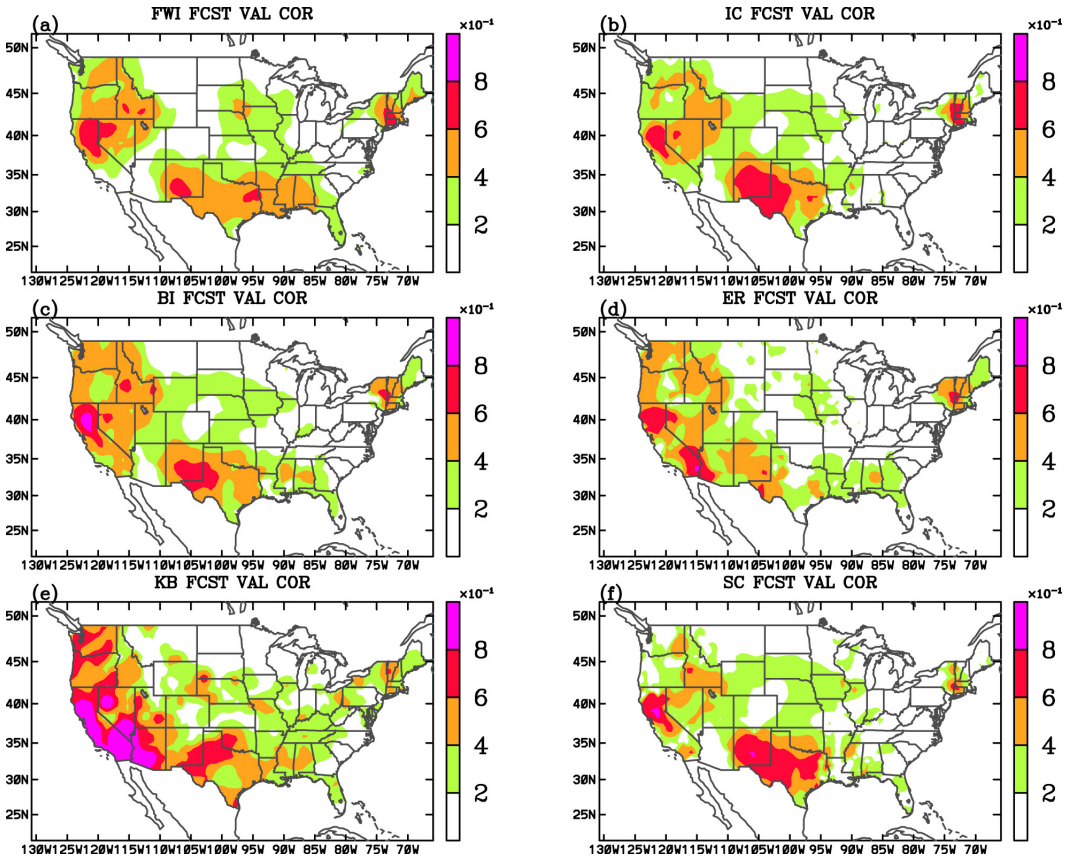


Figure 1. Summer seasonal mean correlations between fire danger forecasts and validations (a) Fire Weather Index; (b) Ignition Component; (c) Burning Index; (d) Energy Release; (e) Keetch Bryam Drought Index; (f) Spread Component.

IMPACT OF CLIMATE VARIABILITY ON EASTERN NORTH PACIFIC SEA LEVELS

Peter D. Bromirski, Arthur J. Miller and Reinhard Flick (SIO)

Link to NOAA Strategic Plan:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Determine if long period (interdecadal) changes in relative sea level height (SLH) observed in tide gauge records along the U.S West Coast can be modeled by large scale changes in North Pacific Ocean circulation resulting from altered atmospheric forcing

(wind stresses and surface heat fluxes). Determine the importance of coastally-trapped Kelvin-type waves on monthly to annual SLH variability observed in tide gauge data along the West Coast by comparison of tide gauge data with modeled SLH.

APPROACH/EVALUATION AND METHODOLOGY

Non-tide residuals (NTR) for nine tide gauge stations from San Diego, CA to Ketchikan, AK, provided an estimate of local meteorologically-forced changes in sea level height (SLH). NTR include SLH fluctuations due to barometric pressure changes and local winds as well as other local-to-regional monthly-scale forcings. Removing the NTR from the raw tide gauge data gives meteorologically-corrected data sets to be compared with modeled SLH changes. The broad-scale spatial and temporal SLH variability can be estimated by EOF and principal component analysis of monthly meteorologically-corrected tide gauge data anomalies, to be compared with modeled SLH anomalies obtained from a primitive equation general circulation model.

RESEARCH ACCOMPLISHMENTS

Nine tide gauge records along the U.S. West Coast of greater than 65 years duration have been obtained for comparisons of sea level height variability with modeled changes from a primitive equation general ocean circulation model forced by COADS wind stress and surface heat flux anomalies (that include trends) from 1945-present. Mode 1 EOFs of meteorologically-corrected (MC) monthly SLH anomalies (monthly means – long term monthly means) show SLH at all stations from San Diego, CA to Ketchikan, AK co-varying. EOF's for mode 2 have a distinct north-south pattern, with a change in sign of the EOFs between San Francisco and Crescent City, CA, similar to results presented by Chelton and Davis used tide gauge time series less than half as long from a different set of stations.

The principal component (PC) time series, associated with de-trended anomalies that produce EOF mode 1, have significantly elevated levels during the 1940-41, 1957-58, 1982-83, and 1997-98 El Ninos. These peaks in PC1 evidently indicate heightened SLH anomalies along the West Coast that result from broad-scale changes in forcing during those time periods.

PC2 associated with non-detrended MC anomalies for data from about 1933-2000 shows an upward trend similar to that obtained by Chelton and Davis (1982), but include data for the 1940-41, 1982-83, and 1997-98 El Nino episodes that was not available for Chelton and Davis study. Elevated PC2 levels are observed during these strong El Nino periods. Because meteorologically-related forcing has been removed from the data, these elevated levels support the hypothesis in our proposal that broad-scale forcing over the North Pacific affects SLH along the U.S. West Coast.

Figure 1. Tide gauge station locations.

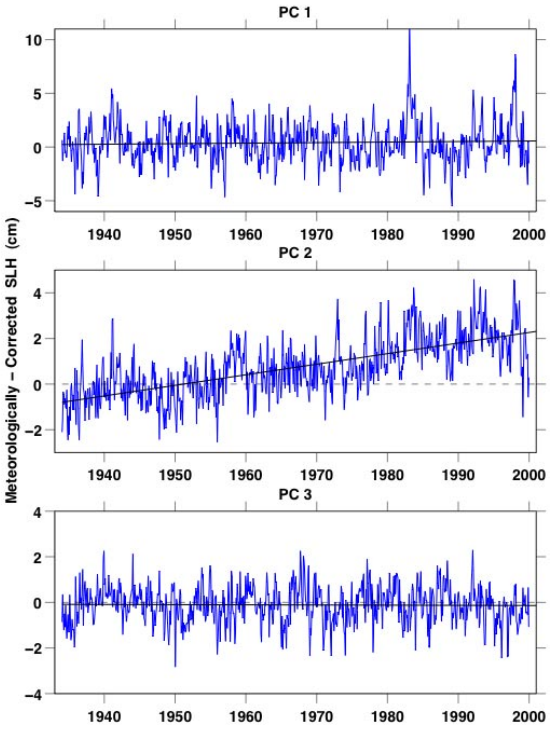


Figure 2. Principal components of monthly sea level height anomalies associated with EOF modes 1, 2, and 3. Least squares upward trend for PC2 (black solid line) is in general agreement with results of Chelton and Davis.

SUMMERTIME ATMOSPHERIC HYDROLOGIC CYCLES

John Roads (SIO)

Link to NOAA Strategic Plan:
Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Model the US hydrologic cycle with a focus on the large-scale summertime hydrologic cycle associated with the southwestern branch of the North American monsoon.

APPROACH/EVALUATION AND METHODOLOGY

A global to regional modeling system developed at the National Centers for Environmental Prediction (NCEP) was used to produce regional simulations of the summertime atmospheric hydrologic cycle in this region. Continuous simulations of seasonal (July, August, September) hindcasts for the U.S. Southwest were performed. The modeling system nested the 25 km resolution RSM within daily forecasts from NCEP's global spectral model (GSM); these GSM forecasts were initialized using NCEP's operational analysis data. Importantly, the regional model produced explicitly-calculated sigma-level time-integrated diagnostic budget terms for the water vapor tendency equation. These budget terms were used to analyze the important hydrodynamics of the system. To help with this analysis, diagnostic terms were archived related to the atmospheric hydrologic cycle derived from both reanalysis and

observational data products. From the reanalysis, monthly values of the large-scale horizontal and vertical moisture flux divergence were calculated from 1958-2002. In addition, we also obtained sigma-layer moisture flux divergence estimates related to convective processes, including evaporative and precipitation values. Observationally, both the 1x1-degree monthly precipitation dataset available through GPCC and the 0.25x0.25 degree daily Unified precipitation dataset available through CPC were archived. In addition, developed estimates for large-scale 4xdaily moisture flux divergence values, calculated from radiosonde profiles throughout the domain.

RESEARCH ACCOMPLISHMENTS

Roads developed a preliminary water and energy budget synthesis (WEBS) for the period 1996-1999 from the "best available" observations and models. Besides a summary paper, a companion CD-ROM with more extensive discussion, figures, tables, and raw data is available to the interested researcher from the GEWEX project office, the GAPP project office.

Using results taken from the fine-scale (25km), RSM simulation for the summer of 1999, along with contemporaneous daily surface observations, synoptic variations in climatological summertime precipitation over the southwestern United States were described and analyzed

In addition, using results taken from these simulations, the summertime hydrologic cycle over the southwestern United States were also characterized.

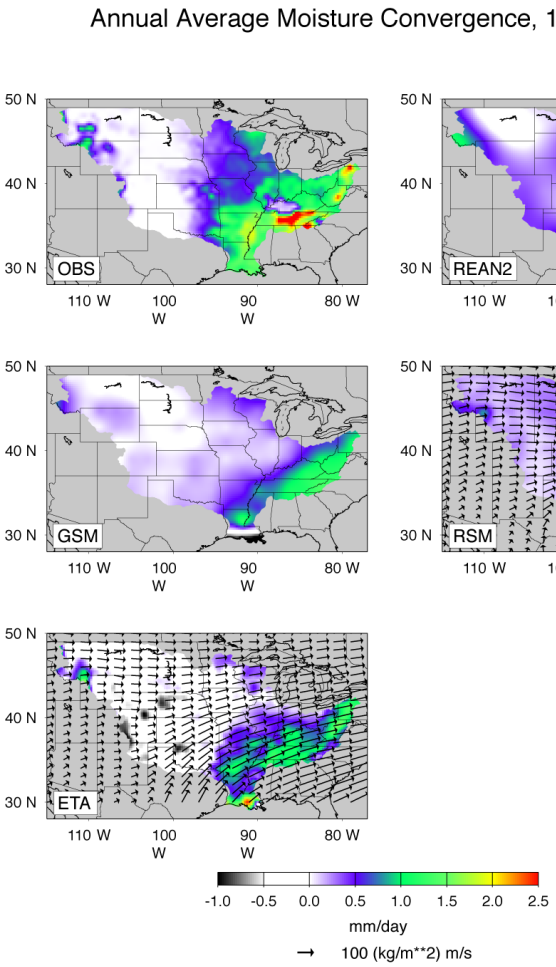


Figure 1. Annual average moisture convergence (mm/day) from the observations and models and analyses (REAN2, GSM, RSM, Eta).

CLIMAS-CAP PARTNERSHIP ACTIVITIES

A. Westerling[1], D. Cayan[1,2], B. Morehouse[3] ([1]CAP, Scripps Institution of Oceanography, La Jolla, CA, [2]USGS, La Jolla, CA, [3]CLIMAS, U. of Arizona, Tucscon, AZ)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

We characterize the key information flows and decision nodes through which strategic planning for fire management occurs. A primary component of this research is characterizing decision calendars for fire management. Understanding the structure of strategic planning, key individuals, and major potential entry points for climate and other information will provide us with the information we need to proceed with a structured economic analysis of climate impacts on fire and, by extension, the value of climate information.

APPROACH/EVALUATION AND METHODOLOGY

Written surveys and interviews of fire and fuels managers at local, regional, and national levels, provide information and insights into the decision processes, information flows, and decision nodes used in wildfire planning and management, and allow the construction of decision calendars showing how climate information needs vary seasonally, over space, and through the organizational network.

RESEARCH ACCOMPLISHMENTS

We identify potential for fostering use of climate information, including seasonal to interannual climate forecasts at all organizational levels, ultimately opening possibilities for improved targeting of fuels treatments and prescribed burns, more effective positioning and movement of initial attack resources, and improved staffing and budgeting decisions. Longer-term (decadal) forecasts could be useful at the national level in setting budget and research priorities. We examine the kinds of organizational changes that could facilitate effective use of existing climate information and climate forecast capabilities.

PREPARATION AND ANALYSIS OF AN EXTENSIVE HISTORIC DATA SET OF OCEAN CARBON DIOXIDE PARTIAL PRESSURE AND RELATED MEASUREMENTS

Charles D. Keeling (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission; Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond; Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

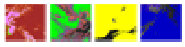
Prepare an analysis of an historic oceanic CO2 partial pressure (pCO2) data set.

APPROACH/EVALUATION AND METHODOLOGY

We have updated the methodology for calculating pCO2 from chemical properties of sea water samples, collected at sea and chemically analyzed in our shore laboratory. This revised methodology allows us more reliably to link historic from underway measurements at sea from 1957 to 1967 to our subsequent shore-based measurements of chemical properties.

RESEARCH ACCOMPLISHMENTS

We have revised our procedures for calculating pCO2 from shore-based measurements of dissolved inorganic carbon, titration alkalinity, salinity, and in situ temperature. We have used revised equilibrium constants and we have incorporated more refined adjustments to the calculation of carbonate alkalinity, taking account of all nutrients which influence the titration alkalinity. We have also made use of special intercomparisons of underway and shore-based pCO2 data carried out in the 1990's. These efforts will allow us to relate the historic data with modern data more precisely by minimizing calibration bias.



POTENTIAL APPLICATION OF RECENT COLLABORATIVE RESEARCH RESULTS TO OPERATIONAL ACTIVITIES AT THE NATIONAL WEATHER SERVICE, ALASKSA REGION

James J. Simpson (SIO)

Link to NOAA Strategic Plan:

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond;
Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

In collaboration with Dr. Gary Hufford (U.S. National Weather Service (NWS), Alaska Region) work continued in several research areas over the past fifteen years, which relate directly to NWS operational activities. Examples include, but are not limited to, airborne volcanic ash detection using satellite data, Alaskan climate (surface temperature and precipitation), and snow hydrology. These research areas relate directly to NWS's aviation weather mission, new climate services program and River Forecast Center (RFC) activities, respectively. Lynn Sherretz of NOAA's Forecasting Systems Laboratory, for example, has been funded to develop a "Test and Evaluate a Volcanic Ash Coordination Tool (VACT)" based on our published, NWS-co-authored research and operational recommendations. In fact, this activity was presented, along with some of our climate-related work, to both the former Director of NWS, General J. Kelly and to the current Director of NOAA, Admiral C. Lautenbacher. Our Alaskan climate analyses are also being utilized by NOAA's National Climate Data Center (NCDC) as it sets up its Climate Reference Network (CRN). Moreover, the Alaskan Regional RFC asked for our help based on our most recent hydrologic study (again, co-authored with Gary Hufford).

The objective of this study, done at the request of NWS, Alaska Region, is to synthesize the research results from the ten (10) most recent collaborative research efforts between Dr. Gary Hufford and Dr. James Simpson into a set of recommendations for potential improvement in Alaska-specific operational forecasting methods. Dr. Gary Hufford and Dr. Simpson have worked jointly to prepare a concise set of specific recommendations and the bases for these recommendations. In this context, Dr. Hufford's expertise and familiarity with the NWS Alaskan Regional operational activities has been most helpful. Many of these recommendations for operational implementation were incorporated into the ten (10) scientific papers.

APPROACH/EVALUATION AND METHODOLOGY

A combination of satellite-based retrievals of application-specific analyses products, atmospheric advective /diffusion modeling and statistical analyses of large in situ data sets was used to perform the analyses describe in the cooperative research between NWS Alaska Region (Dr. Gary Hufford) and UC San Diego / Scripps Institution of Oceanography (Dr. James J. Simpson), described in this report. Where appropriate, mathematical methods of data fusion were used to blend results from the three basic types of analyses/data types. Forecasting needs for a specific application were identified jointly by scientists at UC San Diego / Scripps Institution of Oceanography and the operational meteorological agencies (U.S. National Weather Service, Canadian Meteorological Center). Results were compared with operational needs to determine possible failure nodes of an operational analysis and to make specific recommendations for improvement. Throughout this process, operational personal were involved to help evaluate results in specific forecasting / operational needs areas. Collectively, these efforts and research papers provide a sound theoretical / observational basis for potentially improving some Alaska-specific operational forecasting capabilities. Our efforts concentrated on three broad areas: 1) the aviation hazards to both commercial and general aviation of airborne volcanic ash; 2) Alaskan climate; and 3) snow / river ice hydrology and its relation to more accurate streamflow modeling, water resource allocations and flood mitigation.

RESEARCH ACCOMPLISHMENTS

Three separate areas of research activity are discussed:

Air-Borne Volcanic Ash. Seven scientific papers resulted from the satellite-based airborne volcanic ash analyses (see Figure 1 below). NOAA recently elected to fund the development for a new system to test and evaluate a Volcanic Ash Coordination Tool (VACT) by NOAA's Forecast System Laboratory, Boulder, Colorado, Lynn Sherntez Principal Investigator. This VACT tool is based on the analyses of the eruption of Mt. Cleveland, Alaska. Dr. Simpson also served as a lead instructor at the National Weather Service's Airborne Volcanic Ash Aviation Safety Workshop held in Anchorage, Alaska May, 2002. This workshop was attended by multiple / international representatives from interested government agencies and from operations people (*e.g.,* chief pilots, meteorologists, operational officers) from various international / regional airlines.

Alaskan Climate. A climatological surface temperature and precipitation analysis was needed for a wide variety of forecasting issues in Alaska. We analyzed the recently available PRISM data set for seasonal and longer variability in Alaskan surface temperature and precipitation to meet this need. (Simpson *et. al* 2002b)

As part of NOAA's new Climate Reference Network, the need arose to determine the optimal sites for new and improved climate sensors in Alaska. Optimal site selection is important for at least three separate reasons: 1) to cover regions of Alaska not currently observed (e.g., high mountain ranges like the Books Range); 2) to locate sensors in regions of largest climate uncertainly; and 3) to optimize the design with the careful attention to cost as limited funds are available for the Alaskan component of the Climate Reference Network. A second climate analysis, which compared modeled surface temperatures and precipitations from two different models (see Figure 2, the ANUSPLIN and the PRISM models), was conducted to determine the regions in Alaska with maximum and minimum uncertainty in our knowledge of space / time variation in long-term surface temperature and precipitation. In addition, specific recommendations for the roll out of NOAA's Climate Reference Network were given in this paper.

Improved Hydrologic Stream Flow Prediction. Stream flow river forecasting is especially difficult in Alaska for a variety of complex reasons (*e.g.,* spring breakup can be sudden and swift; extratropical storms can produce sudden, intense and extensive rainfall). Based on a recent work (Simpson *et. al* 2004a), several improvements in operational stream flow forecasting are now possible. The River Forecast Center (RFC) of the Alaskan Region hopes to incorporate some of these concepts into its operational stream flow forecasts. A global climatological analysis of atmospheric water vapor, based on a combined *in situ* and remote sensing data set, also was performed (Simpson *et. al* 2001a); this study provided information useful for both improved airborne volcanic ash detection and hydrologic stream flow prediction.

Figure 1. Resuspended ash cloud extending from Katmai over Kodiak Island into the Gulf of Alaska as seen in MODIS 250m visible data at 21:23:05 UTC 21 September, 2003.

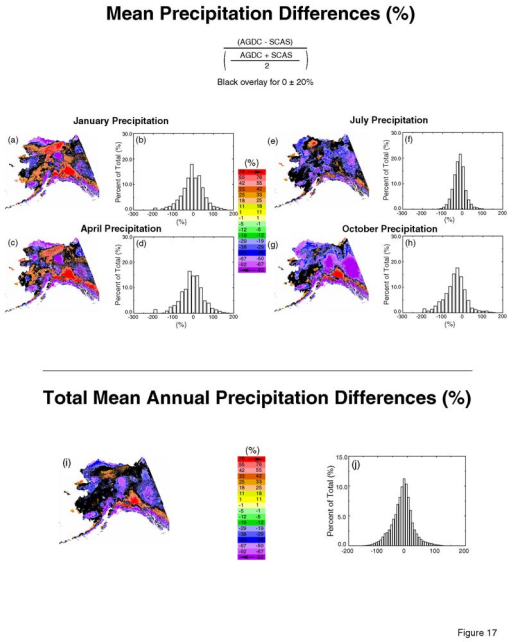


Figure 2. Seasonal and annual precipitation differences in percent between ANUSPLIN and PRISM estimates of precipitation, as indicated.

SUPPORT FOR INTERNATIONAL REGIONAL SPECTRAL MODEL (RSM) WORKSHOP

John Roads (SIO)

Link to NOAA Strategic Plan:

Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond;
Goal 3: Serve Society's Needs for Weather and Water Information

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Provide partial travel support for postdoctoral and graduate students to 5th International RSM workshop in Seoul Korea, Jul. 12-16, 2004.

APPROACH/EVALUATION AND METHODOLOGY

The major purpose of this international workshop was to provide an international forum to discuss the Regional Spectral model RSM. The first few days were devoted to a tutorial session on the RSM. Then the international community involved in the development and application of the RSM described their current research.

RESEARCH ACCOMPLISHMENTS

Over thirty presentations were made at the workshop. Presentations in the following subjects included:

- parameterization improvements - horizontal diffusion, cumulus parameterization precipitation assimilation
- spectral nudging, soil moisture nudging; downscaling - US, CA, US SW, Asia, Brazil, Africa

- coupling to other physical models - land surface models, ocean models
- applications - fire danger, agriculture, avalanches, floods
- evaluations of the parent Global Spectral Model (GSM) - Predictability; Coordinated Enhanced Observing Period
- similar models from other institutions – Florida State University (FSU).

Figure 1. Some of the attendees at the 5th International RSM Workshop, Seoul, Korea, July 13-17, 2004.

SIO'S PARTICIPATION IN US GODAE: SUSTAINED GLOBAL OCEAN STATE ESTIMATION FOR SCIENTIFIC AND PRACTICAL APPLICATION

Dean Roemmich (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The SIO investigators will provide a direct linkage between the assimilation elements of the ECCO GODAE consortium and the Argo float project and other *in situ* ocean observational elements. The use of Argo float profiles is likely to be a major GODAE activity. As with any new data set there are many issues to be confronted for successful use of the data, and the SIO responsibility is to provide the required knowledge of datasets and expertise with instrumentation.

The SIO group will also serve as an interface between assimilation activities and CLIVAR science. The ocean research planned under CLIVAR involves three types of work with ocean data: (a) improvement in seasonal-interannual climate forecasting, including investigation of initialization of the ocean in forecast models – something for which ocean data assimilation is well suited, (b) interpretation of field process experiments focused on improving the representation in models of ocean processes, (c) analyses of

observed climate variability with an ocean focus on individual basins. CLIVAR is working to expand the sustained observations to support this analysis. Our goal will be to use ocean state estimates (or ocean reanalyses) to explore the dynamical processes behind the observed variability.

APPROACH/EVALUATION AND METHODOLOGY

Activities include:

- Participation by D. Roemmich and J. Gilson in design and implementation of Argo delayed-mode quality control. The delayed-mode QC system is being implemented for provision of research quality data from Argo floats.
- Liaison with ECCO data assimilation PIs (B. Cornuelle).
- Research by graduate student E. Douglass, supervised by D. Roemmich, D. Stammer and B. Cornuelle, combines statistical data analysis in the North Pacific Ocean with analysis based on data assimilation results.
- Research by graduate student Josh Willis, supervised by D. Roemmich and B. Cornuelle, applied a regional data assimilation model for better understanding of mid-ocean eddies in a high resolution XBT data set.

RESEARCH ACCOMPLISHMENTS

A manuscript titled “Interannual variability in Northeast Pacific circulation” is in preparation by E. Douglass, D. Roemmich and D. Stammer. Coherent variability on interannual time scales between transport in the subpolar gyre and in the subtropical gyre of the Northeast Pacific is described in both data assimilation model output and in highly resolved datasets. The nature of this variability, and its relation to the changes of the strength of the North Pacific Current (NPC), which supplies the water for both gyres, are explored. Interannual variability in the strength of both gyres is found to be related to both the bifurcation of the NPC, resulting in an anticorrelation between transport in the two gyres, and to variations in its strength, which result in simultaneous changes in the two gyres.

THEME B: BIOLOGICAL SYSTEMS RESEARCH

COOPERATIVE STUDIES OF PACIFIC COAST SALMON: NOAA FISHERIES AND THE UNIVERSITY OF CALIFORNIA, SANTA CRUZ

Pete Adams (UCSC, NOAA Fisheries)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Salmon Population Analysis Team (SPAT) scientists conducted research needed to support (1) salmonid conservation and recovery planning under the Endangered Species Act (ESA) and (2) management of salmonid fishery and harvests. In addition, Team personnel conduct basic research that will provide the underlying theoretical structure of these activities in order to improve the management of salmonids in the future. Specific goals include: to collect or to coordinate collection of critical population distribution and abundance data needed for assessments of salmonid populations; to establish appropriate and statistically robust survey methods and population estimators for use in salmon research and management; to investigate critical salmon life history characteristics (abundance, distribution, mortality, straying, etc.) needed for a comprehensive management approach to Pacific salmon and steelhead; to develop methods for modeling population viability and metapopulation dynamics for use in ESA assessments; and to provide salmon harvest management guidance, through modeling and focused biological studies.

To achieve these goals, SPAT scientists engaged in research that integrates four broad areas: conservation biology, population ecology, spatial ecology, and quantitative methods. Within these areas, projects include field studies, spatial analysis using Geographic Information Systems (GIS), modeling, and the development of sampling and statistical methods.

APPROACH/EVALUATION AND METHODOLOGY

SPAT scientists employed a wide variety of field sampling and quantitative methods to achieve specific research objectives. Methods included observational and experimental field studies, statistical analysis, spatial analysis using GIS, and modeling. Specific study designs were dictated by the particular hypotheses being tested. SPAT personnel engaged in seven field studies between July 2003-June 2004: (1) distribution of juvenile coho salmon in the South Fork Noyo River; (2) observation probability of juvenile coho salmon and steelhead trout during snorkel surveys; (3) estimation of adult coho abundance from spawner surveys; (4) genetic structure of coastal coho and steelhead populations; (5) life history patterns of *Oncorhynchus mykiss* in the Klamath River Basin; (6) genetic structure of *O. mykiss* above and below dams in southern California; and (7) ecology of *O. mykiss* in small coastal basins with respect to food web interactions. In addition to these field studies, the Team completed a variety of projects related to statistical analysis, GIS-based spatial analysis, and theoretical ecology/modeling.

RESEARCH ACCOMPLISHMENTS

SPAT personnel completed six field studies and initiated another long-term field study, completed a variety of spatial analyses using GIS to identify potentially suitable habitat for salmonids throughout California, initiated the development a statewide coastal salmonid monitoring plan with California Department of Fish and Game, and completed several modeling and statistical projects. Results were presented in 12 publications and 18 presentations. In addition to these research activities, SPAT scientists led NOAA Fisheries Technical Recovery Teams and served on Biological Review Teams engaged in conservation and recovery planning for threatened and endangered stocks of anadromous salmonids

Figure 1. Coho salmon (*Oncorhynchus kisutch*) carcass tagged during NOAA/JIMO spawner surveys to estimate adult population size, South Fork Noyo River, CA, Jan. 2004.

GENETIC POPULATION STRUCTURE OF CENTRAL CALIFORNIA COASTAL SALMONID POPULATIONS

Susan Sogard and Gary Griggs (UCSC, Institute of Marine Sciences)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-Based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

- Determine the population genetic structure of extant runs of coho salmon, chinook salmon and steelhead trout in the Central California Coastal region.
- Identify appropriate broodstock for salmonid recovery efforts.
- Estimates values of population genetic parameters in salmonid populations.
- Evaluate interyear and interbasin variability in population genetic composition.

APPROACH/EVALUATION AND METHODOLOGY

- Evaluation of population genetic structure of three species of salmonid in rivers and streams of the California Coastal region.
- Analysis of microsatellite genes were carried out in the Molecular Ecology Laboratory on the UC Santa Cruz Marine Sciences campus, by a cooperative group of NOAA and JIMO researchers.

RESEARCH ACCOMPLISHMENTS

During the present project period, we have continued the study of the relationships among extant steelhead runs in coastal California streams and rivers using molecular genetic techniques. In the last reporting period, project staff finished genotyped and quality control of all 18 microsatellite markers in approximately 4500 fish, representing most of the salmonid-bearing coastal California streams and rivers between the Klamath River and Monterey County. In this reporting period, extended analyses of these data included the identification of migrant genotypes and the relationship between geographic and genetic distance on several

spatial scales. The steelhead analyses are also being extended to the Klamath Basin in the north and the Southern California ESU in the south. The first journal article describing this work is currently in the final stages of preparation.

In this project period, the set of microsatellite markers developed and optimized for coho salmon were expanded from the 12 reported last year to a total of 18. Genotyping of these 18 loci was expanded to include approximately 4000 fish from populations in 17 river systems, spanning most of the California range of the species. These data were used to infer population relationships and the relative genetic divergence between different temporal and spatial scales. Preliminary applications of this dataset to conservation and artificial propagation issues include an evaluation of several cohorts for potential donor stocks to a captive broodstock/restoration effort in the Russian River and the selection of individuals as mating pairs for the program that will substantially decrease inbreeding and loss of genetic variation.

In the present reporting period, work also began on the analysis of population structure in chinook salmon from the California Coastal ESU. We have developed and optimized 12 microsatellite markers for use in this ESU and have collected samples for approximately 1000 fish. Genotyping has commenced and the preliminary results will be described in the next reporting period.

THE CENTER FOR STOCK ASSESSMENT RESEARCH (CSTAR)

Marc Mangel (UCSC)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Undergraduate, graduate, and post-graduate training in the science associated with the problems of assessing the numerical abundance, spatial distribution, size distribution and reproductive status of commercially important fish species, with the goal of increasing the pool of quantitatively trained scientists for NMFS.

APPROACH/EVALUATION AND METHODOLOGY

A focus on training students and post-docs to use mathematical, statistical and computer models to solve important environmental and ecological problems. Work is grounded in data, and seeks to expand the base of basic knowledge that supports rigorous application of science to real-world problems. Furthermore, research on marine fisheries conducted at CSTAR allows testing theoretical predictions via natural and human experiments on a scale that is appropriate for understanding the dynamics of ecosystems.

RESEARCH ACCOMPLISHMENTS

The work at CSTAR is highly collaborative with academia, NMFS, and the California Department of Fish and Game (CDFG) colleagues. Here we identify the CSTAR member and the project, but in general do not identify collaborators of the students, research assistants or post-docs. Melissa Snover (postdoctoral scientist) developed methods for predicting life history patterns of coho salmon development and return, in relation to environmental and genetic factors. Steve Munch (postdoctoral scientist) developed Bayesian nonparametric methods for stock recruitment analysis, so that the data sets the appropriate form of the stock recruitment function. Suzanne Alonzo (Postdoctoral scientist) headed a team conducting a stock assessment of California sheephead. Visiting Researcher Nichols Wolf evaluated the evidence in support of 10 different hypotheses associated with the decline of the Steller Sea lion. Andi Stephens (graduate student) developed a method for subsetting mixed fisheries data for the determination of appropriate measures of fishing effort in groundfish fisheries. Anand Patil (graduate student) developed persistence-based methods that can be used to identify Essential Fish Habitat and Habitats of Particular Concern. EJ Dick (graduate student) developed likelihood based methods for determining the appropriate characterization of variability in groundfish trawl surveys. Yasmin Lucero (graduate student) developed a simulation model, for a Sebastes-like fish, that can be used assess the appropriate level of model complexity in stock assessments. Kate Siegfried (graduate student) wrote a review of methods for estimating natural mortality, participated in shark cruises, and worked on assessing the contribution that marine protected areas make to conservation of diversity. Director M. Mangel developed (with X. He and A. MacCall) evolutionary based priors for steepness for use in stock assessmemts, (with P. Levin) models for marine reserves and models for selection of habitat of particular concern, (with A. Rosenberg, A. Cooper and G. Steffanson), conducted an analysis of west-coast groundfish trawl surveys and (with M. Bonsall) developed models for the evolution of longevity in the rockfish.

A JOINT PROGRAM FOR TRAINING AND RESEARCH IN MARINE RESOURCE MANAGEMENT MODELING

James E. Wilen, Louis Botsford, and Alan Hastings (UCD)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The primary objective is to train quantitative fishery scientists with tools required to address management policy issues in a modern context. This is being done with a new graduate program of study that integrates ecological and economic theory, and teaches methods of model development, data gathering, model estimation and calibration, and simulation methods. In addition, a collaborative fisheries research program has been developed to engage students and PIs in areas of interest to the Southwest Fisheries Science Center specifically, and in areas of broader interest to the fisheries management community.

APPROACH/EVALUATION AND METHODOLOGY

All three Co-PIs have been involved with supervising and instructing PhD students in both the Ecology and Resource Economics programs as well as in joint and individual research on fisheries management issues.

RESEARCH ACCOMPLISHMENTS

All three co-PIs have ongoing individual and joint research underway that focuses on scientific issues underlying important fisheries management issues. One area of joint interest deals with the role of spatial/dynamic processes in marine systems and their importance to marine protected area siting decisions. Botsford and Hastings have developed conceptual models of larval dispersal in order to understand how areas that encompass species with various kinds of dispersal enhance the persistence of the population. Wilen and Botsford have joint research underway that involves constructing and calibrating a spatial/dynamic simulation model of the Northern California Red Sea Urchin fishery. The model integrates the spatial decisions of fishermen into the fishing mortality component and forecasts how protected areas will impact the complete meta-population after fishermen react to the policy. This model is the first fully spatial and dynamic model that has linked up a biological model with an economic model of decision-making, and new insights have been generated about marine reserve siting with the model. A paper summarizing the results won an award for Quality of Research for Wilen and co-author Martin Smith. Wilen organized an international conference on bioeconomic modeling of spatial/dynamic systems in Trieste Italy. The conference brought applied mathematicians, quantitative ecologists, physicists, and natural resource economists together to discuss strategies for modeling dispersal, invasive species and invasive pests, and epidemics. Both Hastings and Botsford are also engaged in understanding how to judge a population's viability under sparse data conditions as well as exploring how to make management decisions in the face of the kinds of uncertainty typically faced by managers. Wilen has begun research investigating the efficacy of harvester cooperatives as co-management institutions. Two graduate students are investigating harvester cooperatives in the near shore fisheries off Chile and Japan. The investigations will identify institutional structures that have been successful in initiating voluntary conservation measures and examine factors that enhance local cohesiveness and stewardship motives. Mike O'Farrell has been developing methods for identifying the important lifetime egg production parameter in data poor situations. He has developed methods for calculating this indicator of population persistence, using two size distributions from early and current stages of a fishery's development. Mike is applying the method to near shore rockfish in California. The results will be valuable to provide a means of quantifying the status of some populations that are suspected of being vulnerable to collapse.

DYNAMICS AND MECHANISMS OF HAB DINOFLAGELLATE MORTALITY BY ALGICIDAL BACTERIA

Peter Franks and Farooq Azam (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Our objective is to quantify the ability of algae-killing bacteria belonging to the genus *Cytophaga* to influence the population dynamics of the red-tide forming dinoflagellate *Lingulodinium polyedrum*. We will combine controlled microcosm experiments using cultures of axenic phytoplankton and bacteria with simple models to determine the critical dynamics and mechanisms that govern this algal-bacterial interaction. Concurrently, we will then use DNA-probes specific for L. polyedrum-killing bacteria to quantify their abundances in the field and their localization with respect to the dinoflagellate cells.

RESEARCH ACCOMPLISHMENTS

Through enrichment techniques consisting of the addition of mixed bacterial communities from seawater to growing L. polyedrum cultures, we have isolated a bacterium (strain ALC1) that impedes the growth of L. polyedrum. This strain, identified as a member of the family Flavobacteriaceae based on 16S rDNA sequence, is a non-motile, kanamycin-resistant bacterium that can grow to relatively high numbers (2 x 107 cells ml-1) in co-culture with L. polyedrum, without any other external source of organic matter. In addition to impeding algal growth, strain ALC1 induces the dinoflagellate cells to slow down their flagellar motility, sink, and eventually form temporary pellicle cysts (Figure 1). The timing of the initial loss of motility of L. polyedrum (before ecdysis occurs) is dependent upon the quantity of ALC1 cells inoculated: less than 24 hours with 108 bacterial cells ml-1 added, one to two days with 107 cells ml-1, and two to three days for 105 and 106 cells ml-1. We tested the hypothesis that the ability to inhibit L. polyedrum growth is a trait common to marine Bacteroidetes in general, as opposed to this strategy being relatively specific to isolate ALC1. Thirteen Bacteroidetes strains from the Azam laboratory culture collection, previously isolated from Scripps pier, showed no ability to inhibit the growth of L. polyedrum after being added to the algal cultures at a density of 106 cells ml-1 (data not shown). We also tested the hypothesis that ALC1 inhibits the growth of other phytoplankton species, versus this ability being specific to L. polyedrum. ALC1 did not cause growth inhibition to 8 clonal (but xenic) algal cultures, including 4 dinoflagellate species, 2 diatom species, one chlorophyte and one prasinophyte. Based on these results, we conclude that the interaction between ALC1 and L. polyedrum is unlikely to be an indiscriminate one, but that rather a species-specific interaction is occurring. We also tested strain ALC1's algistatic activity against several xenic L. polyedrum cultures: only one was affected similarly to the axenic strain, and 4 strains appeared immune to the effects of ALC1 (one of them being the xenic parent culture of the axenic culture used in previous experiments). The transfer of the unattached bacterial flora from the latter cultures into the axenic L. polyedrum culture passed on this immunity. This demonstrates that other bacteria can prevent the damaging effects of ALC1 on L. polyedrum, as shown previously for other algicidal bacteria (Figure 2). The mechanism of this bacterial-bacterial interaction is currently unknown, and efforts are currently being spent on the isolation of a bacterial strain able to inhibit the algistatic activity of ALC1.

We have also shown that the effect of AlC1 on L. polyedrum varies with the dinoflagellate concentration. At background algal concentrations (<10 cells ml-1, the bacterium has a positive effect compared to no bacteria. At mid-log phase, ALC1 has an algicistatic effect. At stationary algal phase, the bacterium has no effect. Efforts are currently under way to determine the mechanism of this changing interaction.

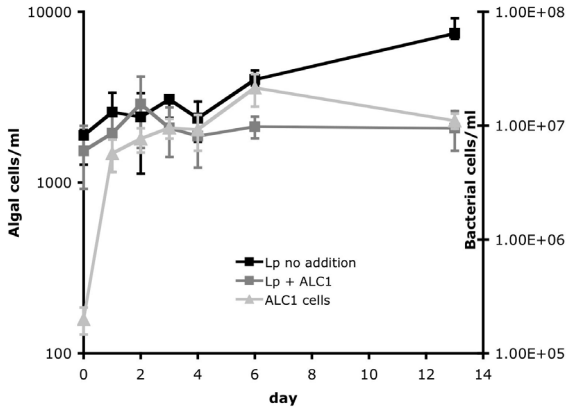


Figure 1. Growth of axenic Lingulodinium polyedrum (Lp) culture with (gray) and without (black) addition of 105 ALC1 bacteria cells ml-1. Each data point represents the mean of three independent replicates and their standard deviation. Bacterial cells (light gray) were counted after DAPI staining (bacteria attached to L. polyedrum cells are not included). Note: from day 2 onward, dinoflagellates in the bacterial addition treatment had decreased motility.

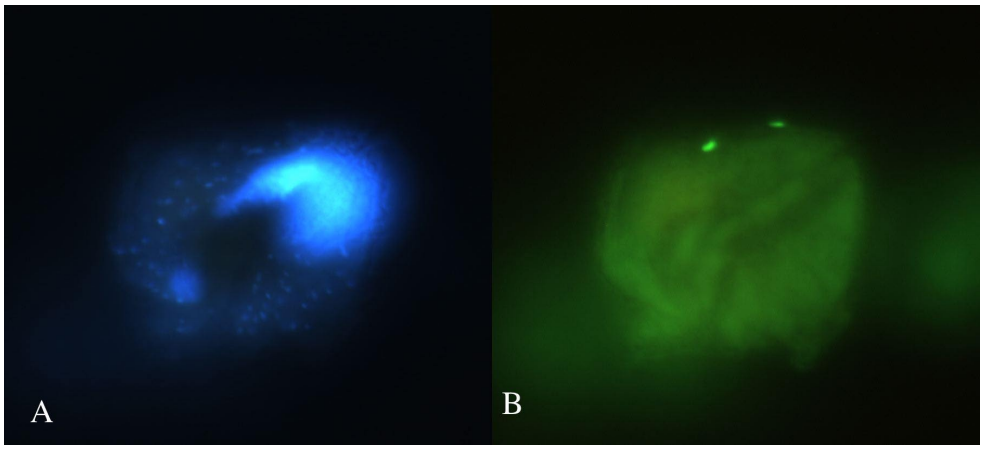


Figure 2. Epifluorescence micrograph showing the same L. polyedrum cell incubated with algistatic bacterium ALC1: A) stained with DNA-binding dye DAPI, B) stained with bacteria-specific DNA probe using TSA-FISH, showing the location of the two attached bacterial cells.

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GROUNDFISH ECOLOGY RESEARCH CRUISE PROGRAM: NOAA FISHERIES AND THE UNIVERSITY OF CALIFORNIA, SANTA CRUZ

Alec MacCall, Stephen Ralston, and Donald Pearson (UCSC)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Groundfish Ecology Program (GEP) scientists conduct research to enhance the basic biological knowledge of as many groundfish species as possible. The data collected by these researchers is used for (1) stock assessments, (2) improve sampling and survey methods, and (3) improve cooperation between the commercial fishing community, academic community, and government research agencies. Specific goals include: collect basic biological data on poorly studied species, identify long term trends in reproduction, improve age determination methods, and examine commercial fishing methods as they relate to fishing strategies.

To achieve these goals, GEP researchers conduct monthly cruises of approximately one day duration on commercial longline and commercial trawl vessels. The actual fishing operations are performed in a fashion typical of commercial fishing operations, using standard fishing gear (with some minor modifications). Each cruise has specific objectives, occasionally aimed at individual species, but more often aimed at answering specific questions such as depth distributions, gear effectiveness, or effect of different fishing strategies on catch.

APPROACH/EVALUATION AND METHODOLOGY

GEP researchers conduct monthly trawl and longline surveys in specific areas off central California. The surveys occur in depths from ten meters to more than 400 meters of water, in a variety of habitats. A variety of groundfish species are tagged and released to examine movement and growth. Samples are returned to the laboratory for aging, maturity, genetic, and fecundity analyses. The research includes scientists from the National Marine Fisheries Service's Santa Cruz Laboratory, UC Santa Barbara, UC Santa Cruz, and Moss Landing Marine Laboratory. In addition, input from commercial fishermen is used for actual vessel operations and to improve study design. Since November of 2001, twenty-seven longline cruises and twenty six trawl cruises have been conducted. During those cruises, more than 25,000 fish have been examined from 61 different species. In addition, 585 fish have been tagged. The cruises are planned to continue for at least two and a half more years. Future plans include: expanding the study area, and evaluating different fishing strategies such as time of day and fishing duration.

RESEARCH ACCOMPLISHMENTS

Currently, one publication on measurement methodology has been submitted to Marine Fisheries Review, two manuscripts are in preparation (life histories of sand sole and green spotted rockfish), and preliminary results of shark and skate studies by Moss Landing Marine Laboratory personnel have been presented at the 2004 West Coast Groundfish Conference.

SHIPBOARD STUDIES OF THE CALIFORNIA CURRENT SYSTEM OFF CENTRAL CALIFORNIA

Baldo Marinovic[1], Francisco Chavez[2], and Curtis Collins[3] 1) Institute of Marine Sciences, University of California, Santa Cruz, 2) Monterey Aquarium Research Institute, 3) Naval Postgraduate School)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management; Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

A collaboration between the Monterey Bay Aquarium Research Institute (MBARI), the Naval Postgraduate School (NPS), the University of California, Santa Cruz (UCSC) and NOAA/NMFS has led to continued quarterly occupations of historical CalCOFI lines off central California. Line 67 was occupied on a quarterly basis between 1988 and 1991 and then again as a result of the 1997-98 El Niño since 1997. Based on discussions started by ACCEO and more recently by PaCOOS it was deemed desirable to continue this important series. Continuous mooring time series in the inner portion of Line 67 (http://www.mbari.org/oasis/) and higher frequency (once every three weeks/monthly) ship (http://www.mbari.org/bog/projects/centralcal/summary/ts_summary.htm; http://cimt.ucsc.edu/research.html) and AUV surveys complement the larger scale, less frequent Line 67 cruises.

APPROACH/EVALUATION AND METHODOLOGY

During winter and spring regular CalCOFI surveys are extended into central California. Researchers from MBARI, NPS and UCSC join the cruises for the Lines north of 77 and collect and analyze samples for chlorophyll and nutrients. CTD casts are extended to 1000 m along Line 67 and time-permitting station spacing is reduced to 10 nautical miles in the inshore portion. In the summer and fall dedicated 4-6 day cruises are carried out by MBARI, NPS and UCSC scientists. To date they have primarily occupied Line 67 but in the future they are expected to occupy Line 60 (off San Francisco) as well. These cruises include the typical CalCOFI measurements as well as other ancillary measurements (see http://www.mbari.org/bog/Projects/secret/default.htm for details). The ability to measure the partial pressure of carbon dioxide in the atmosphere and the sea surface has recently been added to the regular and central California CalCOFI surveys. Funds from the Monterey Bay National Marine Sanctuary (MBNMS) Sanctuary Integrated Monitoring Network (SIMoN) have allowed the hiring of a postdoctoral researcher at MBARI. One of the tasks of the postdoctoral researcher will be to integrate the results of the central California surveys with those in Southern California.

RESEARCH ACCOMPLISHMENTS

FY04 measurements were carried along Line 67 in October 2003 and January and June 2004 (Figure 1). The latter two cruises also included extended observations provided by supported personnel from UCSC, MBARI, and NPS during the winter and spring occupations of the northern lines which are traditionally conducted by the *NOAA Ship David Starr Jordan.* In addition, a supplemental cruise along Line 67 was conducted in July of 2003. Data collected along all Line 67 cruises have been processed for 1) physical oceanographic observations (temp, salinity, ADCP, pCO 2) and chemical/biological observations (nutrients, ChlA , phytoplankton taxonomy, primary productivity, zooplankton biovolume, euphausiid abundance/species composition/size distribution (Figure 2). Results including raw data and depth contours by station have been provided to NMFS personnel in the form of a summary data report on compact disc.

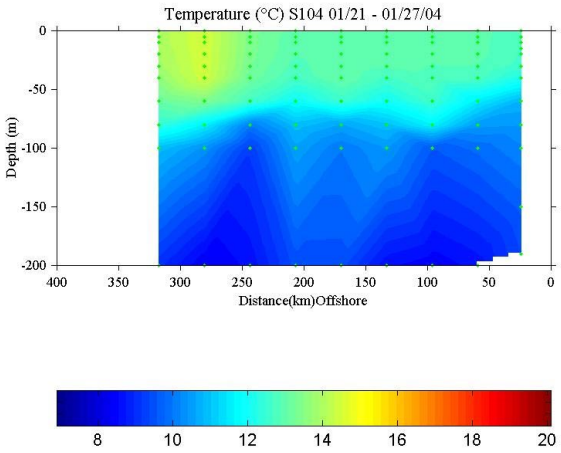


Figure 1. Temperature contours from the January 2004 Line 67 cruise. Distance is measured in kilometers from Moss Landing, CA. The light green dots on the graphs represent data points. These data are from shipboard CTD observations.

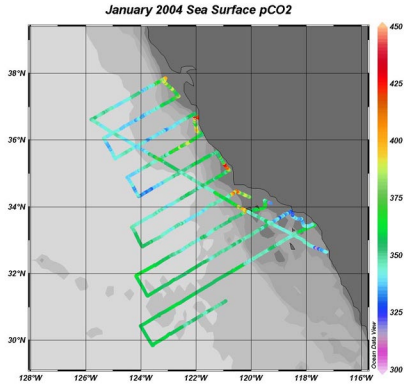


Figure 2. Surface pCO2 measurements taken during the January CalCOFI survey utilizing the newly developed continuous underway sampling system.

CLIMATE-DRIVEN BOTTOM-UP PROCESSES AND KILLER WHALE ABUNDANCE AS FACTORS IN STELLER SEA LION POPULATION TRENDS IN THE ALEUTIAN ISLANDS

George L. Hunt, Jr. (UCI)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Due to their continuing population decline, the western stock of Steller sea lions (*Eumetopias jubatus*) are now listed as an endangered species. Several hypotheses have been generated to explain the declines in populations from Kodiak Island, the Alaskan Peninsula and the Aleutian Island Arc. These hypotheses include: 1) Commercial fisheries act as competitors for a significant fraction of the Steller sea lions' dietary requirements, 2) Increased predation by killer whales (*Orcinus orca*) has influenced trends in sea lion populations, and 3) Changes in climate have affected the productivity of the sea-lion habitat, and thus diminished the abundance or availability of prey for sea lions, particularly in the western portion of their range. The necessary management actions to mitigate the possible effects of the fisheries have severely restricted the inshore portion of the commercial groundfish fishery. To improve the basis for future management decisions regarding commercial fisheries, more information is required about how killer whales and climate variations impact the ecosystem on which Steller sea lions depend. We proposed an integrated multidisciplinary research effort to examine the possible effects of killer whales (Scientific Question D) and climate change (Scientific Question A, in part B and C) on Steller sea lions in the Aleutian Islands. To this end, we quantified primary production, zooplankton distribution and abundance, seabird foraging as an indicator of prey concentrations, and killer whale distribution, and abundance in regions of the Aleutian Islands where sea lion populations are stable and where they are declining. In addition, we collaborated with Phyllis Stabeno, who quantified nutrient concentrations, hydrography and currents within the study areas, and the linkage between the effects of climate change in the North Pacific Ocean and physical responses in the critical habitat of the sea lions. We will also collaborated with Beth Sinclair and Tom Loughlin of the National Marine Mammal Laboratory who will provide satellite data on the foraging distributions of Steller sea lions and enema and scat analyses of their diets. This study was the first multi-disciplinary, integrated examination of the ecosystem in the critical habitat of the western populations of Steller sea lions.

APPROACH/EVALUATION AND METHODOLOGY

A cruise was conducted to the eastern and central Aleutian Islands.

RESEARCH ACCOMPLISHMENTS

During our 2002 cruise, we documented that Samalga Pass was the westernmost pass with a significant northward flow of Alaska Coastal Current Water; a repeat of 2001's finding of a strong east-west gradient in zooplankton species composition; a strong east-west shift in species composition of marine birds and their diets; and strong seasonal and east-west variations in the species composition and abundance of cetaceans. As was the case in 2001, we saw very few pinnipeds in the water anywhere in our study area. We had remarkable opportunities to observe foraging seabirds in a number of passes, but the most impressive were extraordinarily large aggregations of shearwaters foraging on euphausiids at frontal structures at the northwest corner of Unimak Pass. There were more than 100 humpback whales amongst the shearwaters. A remarkable concentration of killer whales was found foraging on fish (that appeared to be salmon) in Samalga Pass. Several groups of what were apparently transient-ecotype killer whales were encountered feeding on a gray whale calf in Unimak Pass. Since completion of the field work in 2002, we organized a symposium during the on the marine ecology of the Aleutians Islands during the February 2004 joint meeting of the American Society of Limnology and Oceanography/The Oceanographic Society, and are nearing completion of a Supplemental Volume of Fisheries Oceanography that should be ready to go to the managing Editor by the end of 2004.

OCEAN AND ESTUARINE PHYSIOLOGICAL ECOLOGY OF SALMON

Susan Sogard and Gary Griggs (UCSC)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Determine spatial and temporal variability of physiological processes, ecological interactions, and the influences of environmental variables on salmonids in estuaries and the coastal ocean of California. Collect salmon, prey, and environmental data in estuaries and ocean; assess, growth, energy dynamics, feeding, and physiological condition in relation to environmental factors.

APPROACH/EVALUATION AND METHODOLOGY

Juvenile salmonids were surveyed and collected in estuaries and the coastal ocean of central California. Chinook salmon were obtained by surface trawl at the entrance and exit to the San Francisco Estuary and at locations along the coast from Pt. San Pedro to Fort Ross out to a depth of 150 m. In concert with trawling, plankton, neuston, chlorophyll and temperature-salinity by depth (CTD) data were collected. Another component of the ocean chinook salmon study, determining stream of origin, was accomplished by determining the $^{87}Sr/^{86}Sr$ isotopic ratio of the juvenile portion of adult otoliths and comparing these values to those of water from Central Valley streams. Adult salmon for this study were sampled from commercial and recreations landings. In small estuaries (Redwood Creek, Marin County; Gazos Creek, San Mateo County; Scott Creek, Soquel Creek, Aptos Creek, Santa Cruz County), coho salmon and steelhead were surveyed by snorkeling followed by seining to collect representative samples. Movement into the estuary was determined by collecting fish in a downstream migrant trap upstream of the estuary. Water quality and flow data were also recorded. For chinook salmon, size and otolith-based age and growth data are used to determine growth. Energy content was assessed by protein and lipid class analyses, and feeding was evaluated by determining the volume and species composition of stomach contents. For steelhead and coho salmon, growth was measured by tag-recapture techniques using PIT (passive integrated transponder) tags, smoltification by gill Na^+, K^+-ATPase activity, and age by scale analysis. The thermal history of steelhead smolts was investigated by fitting fish with temperature archival tags, releasing them into the Scott Creek estuary, recapturing the fish at a later time, and recovering the data from the tag. Steelhead estuarine residence, and growth during residence, was assessed by microstructure and chemical analyses of scale samples. Transects of elemental ratios (e.g., Sr/Ca, Mn/Ca) across the scales were investigated to determine their utility in recording estuary entrance and exit. Salmon data were analyzed in relation to oceanographic and hydrologic data to determine the relationships between physiological and ecological processes and environmental conditions. Research was conducted by UCSC staff, graduate students and researchers from the NOAA Fisheries Santa Cruz Laboratory.

RESEARCH ACCOMPLISHMENTS

Chinook salmon: Cruises in San Francisco Estuary during May and June, and along the central California coast in July and September, collected more than 400 juvenile chinook salmon. Otoliths and size data were obtained from approximately 100 adults at ports from Bodega Bay to Monterey Bay. Juveniles have been examined, measured, and tissues excised for subsequent analyses. Stomach contents have been analyzed; age, growth, protein, and lipid class determinations are in progress. Plankton, neuston, CTD, and other environmental data are presently being entered and subjected to QA/QC procedures. Strontium isotopic ratios have been determined for the adult otoliths.

Steelhead and coho salmon: Estuarine surveys were conducted monthly at all locations except Scott Creek, where sampling was several times per month. More than 2500 juvenile coho salmon and 3500 juvenile steelhead were captured. All juveniles greater than 65 mm fork length received a PIT tag. All fish were measured, weighed, had scales removed and fin clipped (genetic sample); a representative sample at each time/location had a small gill filament sample removed for smoltification analysis. Following these procedures, fish were released. In Scott Creek estuary, 17 juvenile steelhead were fitted with temperature archival tags; four have been recaptured and their thermal history evaluated. For the estuarine residence study, scales have been prepared and mounted on glass slides and are presently being analyzed to determine age and estuarine entry and exit. Chemical analysis will occur during the winter of 2004-2005.

EARLY LIFE HISTORY STUDIES IN ROCKFISH

Susan Sogard (UCSC)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

- Identify essential benthic habitats for young-of-the-year rockfish.
- Integrate long-term datasets on near shore circulation patterns.
- Develop maps using GIS.

APPROACH/EVALUATION AND METHODOLOGY

- Develop new trapping methods to collect YOY rockfishes.
- Use datasets of pelagic juvenile rockfish surveys conducted by NMFS SW Center researchers over last 20 years to identify potential settlement locations.
- Input data to a GIS format to develop maps of spatial locations potentially serving as nursery habitat for newly settled rockfishes.

RESEARCH ACCOMPLISHMENTS

- We have developed and tested a variety of traps to determine their effectiveness in collecting early juvenile rockfishes. The traps have been deployed over high relief, rocky habitat typically occupied by adult rockfishes, over flat sand habitats not likely to be occupied by adults, and intermediate substrates. They have been deployed at depths from 13 m to 60 m, throughout Monterey Bay, during summer months when newly settled rockfish are likely to be present. Trap types included light traps, mesh fish traps, several varieties of minnow traps, and SMURFs (standard monitoring unit for recruiting fishes), modified for deployment in deep water. All of these traps have collected YOY rockfishes, but SMURFs and minnow traps have been more successful. Traps deployed in near shore waters adjacent to kelp beds have collected few Sebastes spp, despite their occurrence in the area based on diver observations. This result suggests that traps may not be effective in areas where abundant natural structure is available. Traps have been more successful in collecting newly settled fishes on sandy substrates with minimal available structure. However, their effectiveness varies depending on species. We plan to conduct laboratory studies to determine how different species respond to the presence of a trap.
- Compilation of results from the 20+ year dataset on pelagic juvenile rockfish, conducted with mid-water trawls throughout central California waters, has provided clear spatial trends in where prospective settlers are likely to occur in higher numbers in Monterey Bay. The southern half of the Bay may be an important area of concentration for pelagic juveniles of several Sebastes species.
- Habitat maps for Monterey Bay in GIS format have been acquired and used to determine sampling locations. High habitat heterogeneity in the bay will provide a valuable template for testing the relative importance of habitat vs. physical delivery mechanisms in identifying essential fish habitat for new settled individuals.

GENETIC POPULATION STRUCTURE OF CENTRAL CALIFORNIA COASTAL SALMONID POPULATIONS

Susan Sogard and Gary Griggs (UCSC)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Determine the population genetic structure of extant runs of coho salmon, chinook salmon and steelhead trout in the Central California Coastal region.

- Identify appropriate broodstock for salmonid recovery efforts.
- Estimates values of population genetic parameters in salmonid populations.
- Evaluate interyear and interbasin variability in population genetic composition.

APPROACH/EVALUATION AND METHODOLOGY

Our evaluation of population genetic structure of three species of salmonid in rivers and streams of the California Coastal region and the analysis of microsatellite genes was carried out in the Molecular Ecology Laboratory on the UC Santa Cruz Marine Sciences campus, by a cooperative group of NOAA and JIMO researchers.

RESEARCH ACCOMPLISHMENTS

During the present project period, we have continued the study of the relationships among extant steelhead runs in coastal California streams and rivers using molecular genetic techniques described in last year's report. In the last reporting period, project staff finished genotyped and quality control of all 18 microsatellite markers in approximately 4500 fish, representing most of the salmonid-bearing coastal California streams and rivers between the Klamath River and Monterey County. In this reporting period, we have extended analyses of these data to include identification of migrant genotypes and the relationship between geographic and genetic distance on several spatial scales. The steelhead analyses are also being extended to the Klamath Basin in the north and the Southern California ESU in the south. The first journal article describing this work is currently in the final stages of preparation.

In this project period, we expanded the set of microsatellite markers developed and optimized for coho salmon from the 12 reported last year to a total of 18. Genotyping of these 18 loci was expanded to include approximately 4000 fish from populations in 17 river systems, spanning most of the California range of the species. These data were used to infer population relationships (Figure 1) and the relative genetic divergence between different temporal and spatial scales. Preliminary applications of this dataset to conservation and artificial propagation issues include an evaluation of several cohorts for potential donor stocks to a captive broodstock/restoration effort in the Russian River and the selection of individuals as mating pairs for the program that will substantially decrease inbreeding and loss of genetic variation (Figure 2).

In the present reporting period, work also began on the analysis of population structure in chinook salmon from the California Coastal ESU. We have developed and optimized 12 microsatellite markers for use in this ESU and have collected samples for approximately 1000 fish. Genotyping has commenced and the preliminary results will be described in the next reporting period.

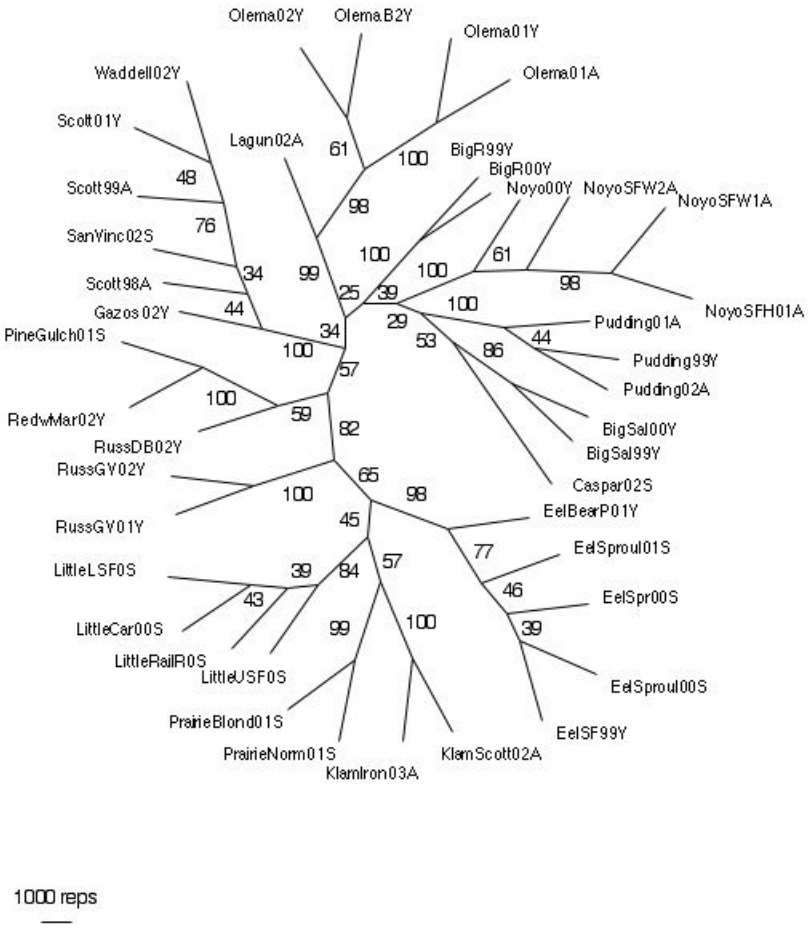


Figure 1. Phylogeographic tree (majority rule bootstrap consensus using chord distances) representing genetic distances between coho salmon from 17 river systems in California. Multiple tributaries and multiple cohorts were sampled for some rivers.

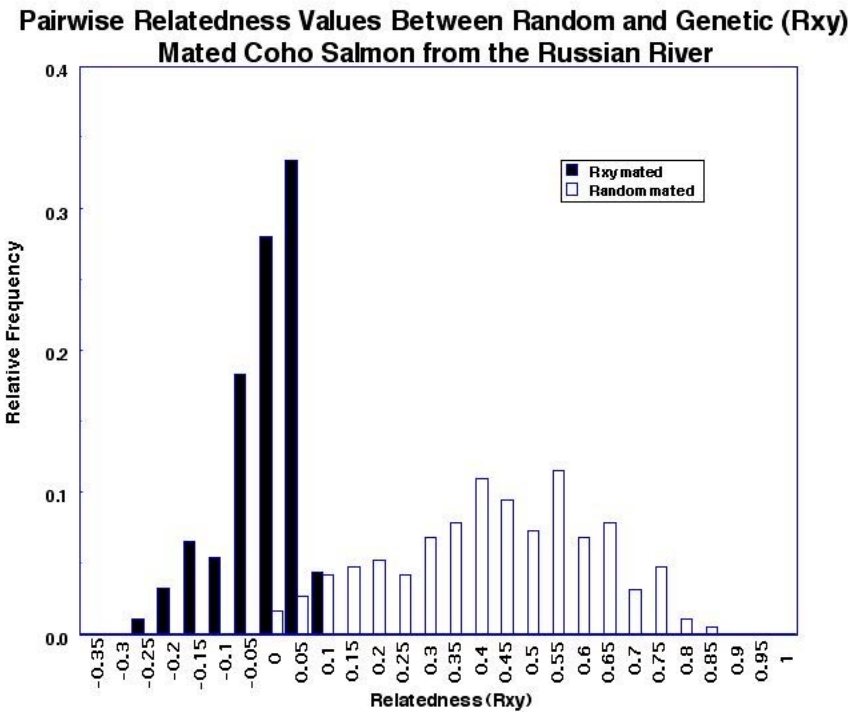
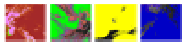


Figure 2: Frequency distribution of coefficient of relatedness (Rxy=.25 for half sibs and Rxy=.50 for full sibs) for breeding pairs of coho salmon from the Russian River captive broodstock program when they are chosen randomly and when they are chosen using project genetic data.



RIGHT WHALE STUDIES IN THE GULF OF ALASKA AND BERING SEA

John Hildebrand (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

The objective of this project is to collect and analyze acoustic data on right whale presence in the Bering Sea and Gulf of Alaska regions. Acoustic recordings provide an efficient means to monitor for the presence of marine mammals. The ultimate goal of this research is to develop techniques for acoustic census of right whales.

APPROACH/EVALUATION AND METHODOLOGY

The present project has two components:.

Task 1: Bering Sea ARP refurbishment

We refurbished and deployed two ARPs in the Bering Sea during May 2004 using the NOAA Ship Miller Freeman. These instruments will record acoustic data for one year at a 1 KHz sample rate.

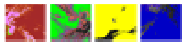
Task 2: Bering Sea and Gulf of Alaska ARP Data Processing

ARP data from 2000-2004 were studied to determine the presence and seasonality of right whales in the Bering Sea and the Gulf of Alaska. The data collected by these instruments are being used by Lisa Munger as part of her PhD dissertation research on the acoustic census of marine mammals in the Arctic. In addition, Lisa Munger traveled to Barrow, Alaska, to participate in an NSF sponsored research cruise, and during this cruise she collected visual and acoustic data on marine mammals in the Arctic.

RESEARCH ACCOMPLISHMENTS

Using a combination of automated spectrogram cross-correlation and manual examination of data, we have detected right whale calls throughout the entire ARP data set. The ARPs provided new information on the seasonality of right whales occurring in the southeast Bering Sea: the latest calls of the year were detected in late October/early November in both 2000 and 2001; the earliest calls of the year were detected in late May 2002.

We have investigated three techniques for localizing or ranging to calling animals within our data set. The first relies on the arrival of a call on multiple hydrophones, and calculates the intersection of hyperbolae based on the call arrival time differences between hydrophones and a known sound velocity profile (SVP) for the Bering Sea during the time of year at which calls were recorded. The second technique relies on the use of two or more directional hydrophones that give compass bearings to the sound source, which intersect at the location of the animal (used for 2002 DIFAR sonobuoy recordings). The third technique models the dispersion of normal modes in the relatively uniformly flat and shallow Bering Sea middle-shelf region, and once a reliable model is tested, the technique can be applied to find the range to a call recorded on a single hydrophone. Another advantage of this third technique is its ability to estimate the depth of the calling animal.



EXTENSION OF PAIRED OCEANOGRAPHIC-WHALE CALL SAMPLES

John Hildebrand (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Over the past three years the NOAA National Marine Mammal Laboratory has used NOAA/Fisheries-RPS funds to develop and deploy Acoustic Recording Packages (ARPs), with colleagues at Scripps Institution of Oceanography (SIO). ARPs have been successfully deployed in the Bering Sea and resulted in a significant extension in sampling of the temporal distribution of critically endangered North Pacific right whales there. Here, we seek support to continue this collaboration, specifically to develop and deploy two High-frequency ARPs (HARPs) capable of recording high-frequency data.

APPROACH/EVALUATION AND METHODOLOGY

The present project is to construct and deploy two HARPS offshore from Washington to augment and extend the acoustic/oceanographic data series in that area. These instruments sample at 80 KHz (40 KHz maximum frequency) to provide data on odontocetes.

RESEARCH ACCOMPLISHMENTS

The two HARPS were deployed using the University of Washington research vessel Centennial during July 2004. The work was performed in accordance with permit OCNMS-2004-004. The final locations and instrument descriptions are: 47 21.797'N 124 45.388'W (80 fathoms). The mooring stands 5 fathoms off seafloor, with a top float at 75 fathoms depth. The second HARP mooring is at 47 26.894'N 125 08.308'W (500 fathoms). The mooring stands 6 fathoms off seafloor, with a top float at 494 fathoms deep.

PHYSICAL, CHEMICAL AND PHYTOPLANKTON TIME-SERIES DATABASE FOR THE ANTARCTIC MARINE LIVING RESOURCES (AMLR) SURVEYS, 1990-2002

Osmund Holm-Hansen and Christopher Hewes (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

A database will be incorporated into a larger database under construction by the NOAA-AMLR group that contains zooplankton (krill), marine bird and mammel taxonomy and abundance within the Antarctic Peninsular region. This will help in modeling efforts relating primary production to higher trophic levels of the Antarctic food web.

APPROACH/EVALUATION AND METHODOLOGY

Historical data files (having various computer formats) of physical, chemical and phytoplankton content (1990-2002) from shipboard ecosystem studies of the Antarctic Peninsula were compiled into a single relational database format.

RESEARCH ACCOMPLISHMENTS

Collated twelve years of time-series data collected during the Antarctic Marine Living Resources (AMLR) program (1990-2002) into a single unified database. The concern of this project included only data related to phytoplankton dynamics and physical oceanography.

PHYTOPLANKTON STUDIES IN COOPERATION WITH THE U.S. ANTARCTIC MARINE LIVING RESOURCES (AMLR) PROGRAM, JANUARY-MARCH, 2004

Osmund Holm-Hansen (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 1: Protect, Restore, and Manage the Use of Coastal and Ocean Resources through Ecosystem-based Management

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

Our overall objective is to obtain sufficient data on the biomass distribution (horizontal and vertical) of phytoplankton so that the inter-relationships between the primary producers, the physical/chemical/optical environment, and the food requirements for krill may be better understood. Our shipboard studies utilized the following:

- sensors that automatically record data in a central computer (operated by the physical oceanography component of AMLR)
- discrete water samples for measurement of chlorophyll concentration in the euphotic zone.
- images of chlorophyll distributions for the Drake Passage and AMLR survey area from the MODIS (Aqua) satellite.

APPROACH/EVALUATION AND METHODOLOGY

The Antarctic Marine Living Resources (AMLR) program is the US component of an international program (CCAMLR) to assess the stock and production of krill in the Southern Ocean and the impact of their harvest upon higher trophic levels. The AMLR study area around Elephant Island is known to be very productive for krill and higher trophic levels, and has been one of the major areas for commercial harvesting of krill. The reasons why this area is so rich in krill and higher trophic levels such as birds and seals are not well understood, but it is thought to be related to the varied bottom topography (including extensive shelf regions) and to the existence of mixing zones between the various water masses encountered in this area. Much of the waters in the AMLR study area thus have high inorganic nutrients, including iron, and fairly well developed upper mixed layers. These conditions result in high phytoplankton biomass and in high, sustained rates of primary production. Our participation with AMLR since 1990 has involved work aboard ship mid-January through mid-March, with ship operations including two ~28 day Legs. For each Leg during 2004, a CTD carousel and independent profiling units were used to obtain samples of the water column for analyses as well as to obtain data from various profiling sensors as listed below:

- Water samples were obtained from 10-liter Niskin bottles (with Teflon covered springs) which were closed at 10 standard depths (5, 10, 15, 20, 30, 40, 50, 75, 100, and 200m) from every station upcast of the CTD/rosette unit.
- A Sea Tech transmissometer was used to determine the attenuation of collimated light (by both scattering and absorption) during CTD casts.
- A Sea Tech profiling fluorometer was used to measure in situ chlorophyll fluorescence.
- A Biospherical QCP200L profiling PAR (photosynthetic available radiation) sensor was used to measure the in situ light regime.

RESEARCH ACCOMPLISHMENTS

As in previous years, chlorophyll concentrations have generally increased between Legs I and II for shelf and shelf break areas, and this year there were only slight differences. Although concentrations were moderately low for all areas in the AMLR survey area relative to our 15-year time series, chlorophyll concentrations did increase slightly during Leg II. Satellite imagery also indicated this same trend, with moderate chlorophyll increases in the local waters near Cape Shireff, and a dense bloom in the Bransfield Strait. In cooperation with the Global Drifter Program (P. Niiler, SIO), 40 drifter buoys were deployed this season: 10 during AMLR Leg I, seven along the transect between King George Island and Punta Arenas (February 4-5, 2004), and 23 during the collaborative NSF-OPP project (February-March 2004). Data from these drifters indicated a deflection in the drift of the Antarctic Circumpolar Current (ACC) imposed by the Shackelton Fracture Zone (SFZ), similar to that described from drifter trajectories from the 2002/2003 field season.

Nutrients were sampled at selected stations within the AMLR survey grid that have, from past analyses, provided extremes in physical and biological characteristics of the water column for the Drake Passage side of the South Shetland and Elephant Islands. The macronutrient distributions in the water column, indicate that the upper mixed layer (UML) for ACC waters contained much higher ammonia, and much lower silicate concentrations than coastal waters, and only slight differences in nitrate and phosphate.

We found that macronutrient concentrations were quite similar at 200 m, and assume that deep mixing during winter would result with similar nutrient concentrations through the upper water column. Thus, differences between macronutrient values in the UML and deep water are often interpreted to represent the amount of carbon export to the deep ocean. The N_{total}:P ratio for all data are 17.7 ± 1.1, close to the Redfield ratio of 16, and was found to have no relationship with depth, location or chlorophyll concentration. Yet stoichiometry was not found for the N_{total}:Si ratio which had great differences both in relation to depth and between ACC and coastal waters. For diatoms, the N:S ratio is ~1.0. It is generally held that nanoplankton dominate low chlorophyll containing waters and that large diatoms dominate blooms for Antarctic waters. As silicate is primarily utilized by diatoms, it would be expected that chlorophyll concentration and the macronutrient N:S ratio should be positively correlated in the UML. This relationship was found for the coastal waters only. A completely different relationship was found for ACC waters. Recent findings demonstrate that under iron limitation, diatoms become more heavily silicified. The ACC in the AMLR survey area can be iron deficient for phytoplankton growth (unpublished results from our current NSF OPP-sponsored project). It would appear that for waters of the ACC, the low biomass and nanoplankton dominant communities have produced and exported a relatively greater proportion of diatom biomass than the more productive waters of the AMLR survey area. As these ACC waters can have high ammonia concentrations that might effectively reduce the requirement of iron for diatoms, one could speculate that ACC waters have communities with a higher ratio of diatoms to other types of phytoplankton relative to total biomass than as found in the other types of within the AMLR survey area

THEME D: R & D ON OBSERVATIONS SYSTEMS

JOINT PROJECT AGREEMENT CONCERNING THE NATIONAL SPATIAL REFERENCE SYSTEM IN CALIFORNIA

Yehuda Bock (SIO)

Link to NOAA Strategic Plan:
NOAA's Mission Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

NOAA's National Geodetic Survey (NGS) and the California Spatial Reference Center (CSRC) have joined in partnership for the purpose of researching spatial referencing and height modernization for the public good. Although focused on California, our goal is that our research will contribute directly to the development by the NGS of public guidelines and procedures for other states and entities interested in implementing height modernization and spatial reference systems. The specific objectives of the project are to research and implement the scientific and infrastructure basis for the California Spatial Reference System. There are several outstanding research questions related to spatial referencing that are being addressed, for example:

What is the proper observation mix to maintain a modern height network, and how should these measurements be optimally combined? Observation types include continuous GPS (CGPS) including real-time high-rate networks, field GPS surveys at passive monuments, leveling, and gravity surveys.

What analysis procedures should be applied to these observations, and in what reference frame should they be expressed in, recognizing that California is subject to crustal deformation due to plate tectonic, volcanism, and hydrological effects.

What is the proper mix of geoid models and local corrector surfaces, in converting from GPS-determined geodetic heights to orthometric heights? What interpolation methods will provide the optimal corrector surfaces?

Can we apply and enhance modern IT methods to provide timely access to height modernization information?

How does one develop and implement a precise GIS for the purposes of height modernization?

The CSRC has been established to achieve the above research objectives. The R&D and operational arm of the center is located at Scripps, and leverages the resources of the Scripps Orbit and Permanent Array Center. The CSRC also consists of an Executive Committee, Coordinating Council, and a user community, organized as a UCSD Support Group. Along with our sponsors at NGS, the Exec. Committee provides advice on the research direction, the relevant civil applications, and the allocation of resources. The overall success and management of the project is the responsibility of the PI.

APPROACH/EVALUATION AND METHODOLOGY

The development and implementation of the CSRS will follow these general guidelines:

GPS (and in the future complementary GNSS systems such as Galileo) will provide the CSRS backbone of precise, time-varying coordinates of hundreds of permanent (active) stations in the State.

The underlying reference frame will coincide with the International Terrestrial Reference Frame (currently ITRF2000) or future incarnations adopted by recognized international organizations (IERS, IGS). All GPS analysis and network adjustments will be performed with respect to this frame.

Transformations to national horizontal and vertical datums (e.g., NAD83. NAVD88) after adjustment in ITRF will be performed through jointly (CSRC and NGS) approved transformation and model parameters.

The time-varying nature of coordinates in California will be incorporated into the CSRS. Corrections (e.g., velocities, offsets) will be provided through jointly approved models (SECTOR/HTDP) to allow the user to compute consistent coordinates at any observation epoch.

National geoid models will be the basis of converting ellipsoidal to orthometric heights. Local adjustments will be applied as needed.

The CSRS will maintain a seamless, integrated network so that all corrections (to horizontal or vertical coordinate components) are traceable to a reference epoch. Changes to the reference epoch will be minimized. However, updates to correction models need to be part of an ongoing and timely process, in concert with the scientific community and NGS.

The project is being carried out with a mix of SOPAC/CSRC staff at Scripps, geodetic consultants, private contractors, and CSRC volunteers. SOPAC/CSRC staff and geodetic consultants focus on the research questions and developing the IT infrastructure. The geodetic consultants are involved in data analysis, project supervision, education, and public outreach. Private contractors perform geodetic measurements (leveling and GPS) in support of the CSRC Master Plan.

RESEARCH ACCOMPLISHMENTS

To address the research objectives outlined above we have collected, analyzed, and interpreted data collected in several demonstration projects in California (Figure 1), in support of CSRC's "A Master Plan for a Modern California Geodetic Control Network." In FY2003-2004 we completed an out-sourced height modernization project to level to 20 CGPS sites throughout southern California from pairs of NAVD88 benchmarks. Discrepancies between orthometric heights derived from GPS ellipsoidal heights and geoid models, and leveled heights at some stations indicate that leveling will required for achieving the objectives of the Master Plan. In Northern California the availability of NAVD88 benchmarks is limited and we are currently working with Caltrans on a project to establish 800-900 passive stations in Caltrans North Region. In southern California, we will level to an additional 15 CGPS sites. In northern California, we will supplement the establishment of 800-900 passive stations with leveling, in cooperation with Caltrans. We published a new epoch date (2004.0) for coordinates and velocities for all continuous GPS stations in California, which have been endorsed by our sponsor at NGS. These CGPS stations provide the infrastructure backbone for the CSRS.

In order to facilitate a streamlined and efficient exchange of information during height modernization and geodetic densification performed by the CSRC, we have developed a Web Services based infrastructure of client applications and centralized information servers using SOAP. This initiative takes advantage of extensive experience at SOPAC/CSRC with information management, database design, application development and systems integration for scientific applications. The primary impetus for this initiative is the preponderance of outdated procedures, technologies and information systems design strategies in the GPS community. One of our major accomplishments this year is the development and publication of an XML schema for GPS site metadata.

The CGPS sites from the existing regional networks in the western U.S. are transitioning to UNAVCO's Plate Boundary Observatory (PBO), with full transition, except for about 125 SCIGN sites, to be accomplished by 2008. This will have significant impact on CSRC since maintenance of these existing sites will be secured though the EarthScope/PBO funding. In addition, PBO will establish several hundred new CGPS sites in California, which will need to be integrated into the California Spatial Reference System by computing coordinate time series for these new sites. CSRC personnel are working with PBO regional engineers in southern and northern California, in order to meet the objectives of PBO and CSRC.

We have also followed up on the Orange County Real Time Network (OCRTN) project by facilitating similar networks in San Diego, Riverside and Imperial counties. Currently there are 40 SCIGN stations that have been upgraded to real-time (<1 s latency) high-rate (1 Hz) operations. These stations have detected seismic motion from the 2002 Denali fault earthquake in Alaska and the 2003 San Simeon earthquake in central California, and provide significant outreach opportunities.

Figure 1. Summary of field projects completed or in progress at CSRC. These include the Orange County Real Time Network (OCRTN), leveling to CGPS stations in southern California, county surveys (Contra Costa, Tuolumne, Yolo), height modernization projects in the South San Francisco Bay area and in the San Joaquin Valley and northern California densification in collaboration with Caltrans.

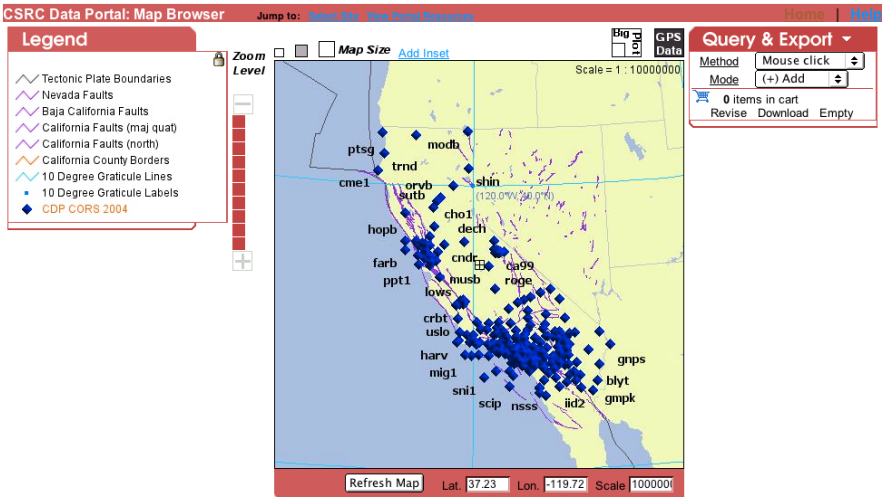


Figure 2. Upgraded Map Browser of the CSRC Data Portal showing the continuous GPS stations which make up the current backbone of the California Spatial Reference System. New epoch date (2004.0) station coordinates and velocities were published by the CSRC and endorsed by NGS for public use.

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IMPLEMENTATION OF A REAL-TIME PRECIPITABLE WATER CAPABILITY USING THE GLOBAL POSITIONING SYSTEM

Yehuda Bock and Peng Fang (SIO)

Link to NOAA Strategic Plan:

NOAA's Mission Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

RESEARCH OBJECTIVES AND SPECIFIC PLANS TO ACHIEVE THEM

To realize the goal of estimating precise (≤ 1.5 mm RMS) integrated precipitable water (IPW) within 2 hours using a network of continuous GPS receivers distributed over the continental U.S. as a way of supplementing and improving numerical weather prediction models, i.e., short-term weather forecasting. At NOAA's Forecast Systems Laboratory (FSL), a ground-based GPS meteorology system has been implemented, with continued scientific input, oversight and refinement from the Scripps Orbit and Permanent Array Center (SOPAC). One of the breakthroughs in the system is the ability to generate quality-controlled, hourly orbital estimates for the GPS satellites at SOPAC, using a 48-hour sliding window in hourly increments. The precision of the orbits is about 7 cm within the observed session and below 15 cm in the predicted 12-hour segment.

APPROACH/EVALUATION AND METHODOLOGY

We have evaluated approaches to provide more robust and timely GPS satellite orbits. These include using longer orbital arcs, introducing more even spatial coverage of data from global GPS tracking stations, and developing redundant and more robust quality control mechanisms. We have also evaluated new methodologies to reduce the latency of derived GPS zenith delays from single-epoch instantaneously estimated zenith delay parameters.

The co-PI (PF) interacted closely with our sponsor at FSL (Seth Gutman and his staff) to enhance the FSL system. The PI (YB) worked with the sponsor to evaluate the instantaneous zenith delay estimation approach.

RESEARCH ACCOMPLISHMENTS

High quality orbits are now delivered hourly with better than 99% (2 interruptions over a 365 day period) reliability with a precision of about 7 cm, and a predictive capability of 15 cm . A redundant processing system has been implemented to improve the reliability of GPS orbit support at SOPAC for NOAA. An instantaneous tropospheric delay estimation system using a dense continuous GPS network in southern California has been shown to provide useful information for GPS meteorology.

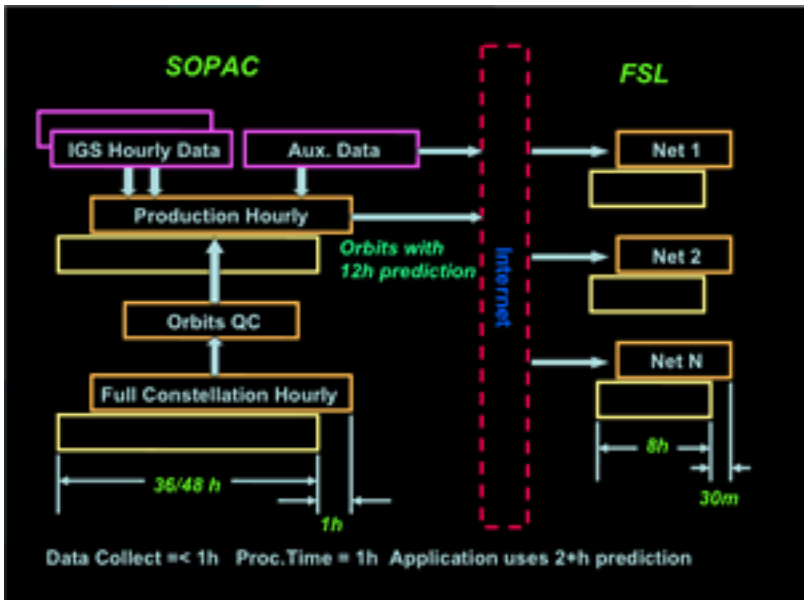

Figure 1: Wiring diagram of the hourly orbit determination system developed at SOPAC to support GPS meteorology at NOAA FSL.

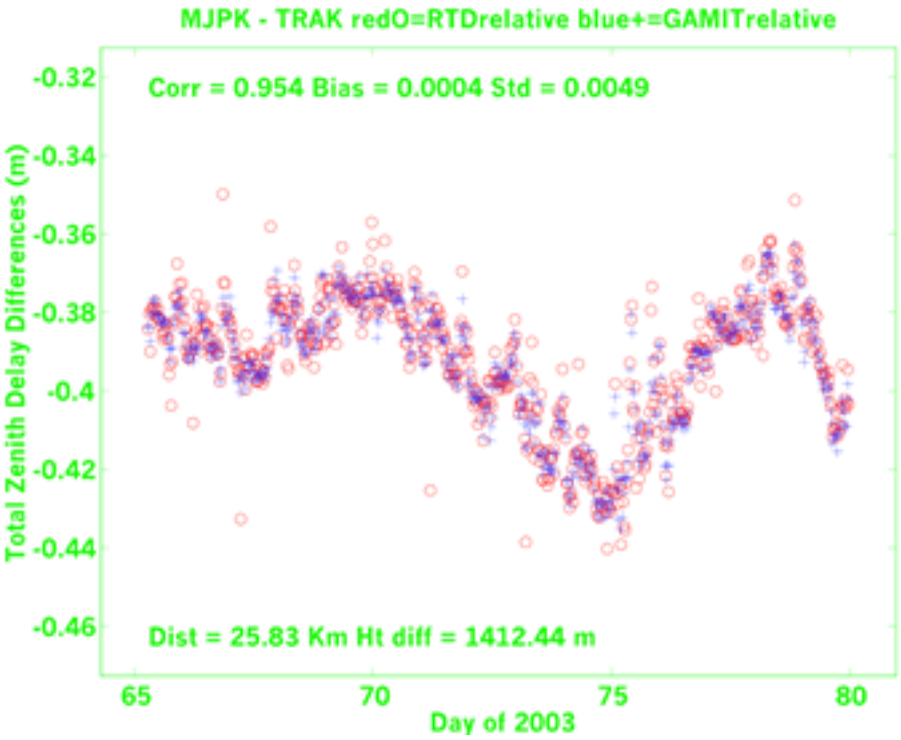

Figure 2: Comparison of 30-minute relative zenith delay estimates between two sites in Orange County, California, between the GAMIT software and averaged real-time instantaneous (1 sec) estimates. RMS difference is 4.9 mm or less than 1 mm in precipitable water.

COMMUNICATIONS, NETWORKING & OUTREACH

ACTIVITY TYPE	OBJECTIVE	PARTNERS
Communications		
Conference on Communications of Forecast Data	Bring together collaborators on communications efforts in North America	NOAA/OGP and Rutgers University
Special issue of Deep-Sea Research devoted to "CalCOFI: A Half Century of Physical, Chemical and Biological research in the California Current System"	Present recent research accomplishments of CalCOFI and allied programs	Edited by D. Checkley (JI) ,S. Bograd (NOAA) and W.S. Wooster (UW)
ARGO web site www.argo.ucsd.edu	Provide a focal point for the public and ARGO participants to find information, progress and access data.	
ARGO Newsletter (Argonautics, W. J. Gould, ed.)	Facilitate communication on recent developments, achievements and issues of interest to the broad Argo community.	
Project web sites: http://www.ldeo.columbia.edu/res/div/ocp/CORC-ARCHES/ http://www.ldeo.columbia.edu/res/div/ocp/projects/corc.shtml		
Experimental Climate Prediction Center http://ecpc.ucsd.edu	Provide experimental climate forecasts and graphical to general public and various researchers.	
Web Pages: CAP/CCCC page: http://meteora.ucsd.edu/cap California Climate Data Archive: http://www.calclim.dri.edu/ California Vectorborne Disease Surveillance System: http://vector.ucdavis.edu/arbo.html		
AGU, AMS, CEOP Meetings	Describe early research results with CEOP output	AGU/AMS/CEOP
Advice to California's Coastal Ocean Current Monitoring Program (Prop 40)	Provide advice to the Coastal Conservancy on design of monitoring program to accommodate fishery and marine ecology issues	University of California, California Department of Fish & Game, State Water Resources Control Board, U.S. ACOE, USGS, Sea Grant, SCWRP, Sonoma County Water Agency
Guidance to CalTrans for renovation of Hwy 1 bridge over Scott Creek estuary	Provide recommendations for bridge renovation that minimize impact of project to estuary	California State University, San Luis Obispo, CA
Advice to Census of Marine Life (CoML) Program	Provide recommendations for expansion of CoML program	CoML program staff, representatives from academia, industry, and government
Advice to NOAA Fisheries Northwest Region Protected Resources Division	Provide recommendations on scientific merit of including hatchery	NOAA Fisheries scientists and managers

	salmonids in ESA listings	
Advice to Pescadero Watershed Council on annual fish kill	To determine the causes, consequences, and solution to annual fish kill in Pescadero Creek estuary	NOAA Fisheries, California Department of Fish & Game; Watershed Council, consultants, concerned citizens; San Jose State University
Meeting to form consortium to develop proposal to tag & track salmon and sturgeon in Central Valley	To develop program to monitor movement of salmonids and sturgeon in Central Valley and San Francisco Estuary	NOAA Fisheries, California Department of Fish & Game, consultants, University of California, Davis
CSRC Web Site: (http://csrc.ucsd.edu/	Provide on-line access to CSRC resources	
Publication of on-line semi-annual newsletter ("The Reference Point")	Provide an on-line summary of CSRC progress, news, and activities	Larry Fenske and Bill Young, CSRC volunteers, members Exec. Comm.
Maintenance of mail listservers for CSRC Executive Committee, CSRC Council, and general CSRC membership	Provide a convenient and recordable communications mechanism	
CSRC Semi Annual (Fall) Meeting, Scripps Instituion of Oceanography, October 17, 2003	Semi-annual business meeting of the CSRC Coordinating Council	UCSD's CSRC Support Group
CSRC Semi Annual (Spring) Meeting, PG&E headquarters, San Francisco, May 14, 2004	Semi-annual business meeting of the CSRC Coordinating Council	Hosted for the second year by Pacific Gas & Electric
SOPAC Web Site (http://sopac.ucsd.edu)	Precise hourly orbits are published and freely available	International GPS Service
NETWORKING		
Climate Outlook Forum Participation	Provide quality forecast input to regional COF, develop features of COF useful to forecast user.	WMO, NOAA, OGP and NWFS
PaCOOS Workshops	Develop a marine ecosystem observation network along the west coast of North America	SWFSC and NWFSC/NMFS/NOAA, California State resource agencies MBARI, University of Washington, Oregon State University, Humbolt State University
Modeling Spatial/Dynamic Systems	Develop linkages	Beijer Institute for Ecological Economics in Stockholm Sweden, and with Woods Hole Oceanographic
Economic Effects of Weather and Climate Forecasts to California Energy Production Management	Provide forecast information to decision-makers and energy partners.	• Staffer for U.S. Rep. Randy Cunningham • U.S. Rep Sherwood Boehlert, Chair, House Science Committee • Eric Massa, House Armed Services Staffer • House Science Committee members Rep. Vern Ehlers, Chair of the Environment, Technology and Standards Subcommittee; Rep. Nick Smith, Chair of the Research Subcommittee, and Rep. Jerry Costello, who also serves on the House Transportation and Infrastructure Committee. • SIO director's cabinet meeting (community activists who advise the SIO director) • Dwight Cates, Staff, House Energy & Commerce Committee; Kathryn Clay, Staff, House Science Committee; Mike Conallen, Chief of Staff, Congressman Curt Weldon; Tina Kaarsberg, Staff, House Science Committee; Chris King, Staff, House Science Committee; Ryan Long, Legislative Director,

		Congressman Barton; Peder Maarjberg, Appropriations Director, Congressman Visclosky; Shane Perkins, Staff Assistant, Senate Energy Committee; Chris Heggem, Legislative Assistant, Senator Burns; Neil Naraine, Legislative Assistant, Senator Landrieu; Marsha Shasteen, Democratic Counsel, House Science Committee • Drew Willison and Nancy Olkewitz, Senate Energy and Water Appropriations staff • Dan Skopec, California state deputy Cabinet Secretary for energy and environment • SIO director's council, a group of California executive businesspeople and politicians who advise SIO • Presentation at the International Association of Impact Assessors, people who are involved with planning for the environmental impacts of industry and technology • Annual meeting of the California Climate Registry, business leaders who are working towards a CO2 credit exchange • Ryan Broddrick, Director of the California Department of Fish and Game • Allan Lloyd, Director of California Air Resources Board • Staff of U.S. Rep. Rohrabacher • Michael Chrisman, California Resources Secretary, and Jim Branham, CalEPA Undersecretary • John Wilson, advisor to California Public Utilities Commissioner Rosenthal • Board of Directors, National Corn Growers Association
Ten Year Implementation Plan for the Global Earth Observations System of Systems (GEOSS) and in the review of the	Ensuring that Argo was properly represented in these two documents.	
Global Climate Observing System Implementation Plan. (W.J.Gould)	Ensuring that Argo was properly represented in these two documents.	
NOAA/OGP/CDEP ARCs	Work with other applied research centers associated with NOAA/OGP/CDEP program	NOAA OGP ARCs
Seminar Series “Red Tides: More Growth or Less Death”		University of Victoria, Canada
The SNOSIP Project	Provide quantitative improvements to the Sierra Nevada Basin watershed models.	State of California, Department of Water Resources, U.S. Geological Survey.
IRI/NCEP	Provide routine seasonal forecasts	IRI, NCEP
California Applications Project (CAP)		CALFED: California Bay Delta Program California Department of Water Resources Center for Pacific Rim Health Studies (UC San Diego and SDSU)

		Department of Health Services, California Harvard Medical School Harvard School of Public Health UCSD School of Medicine
Phytoplankton	The data collected will be added to our existing AMLR database that will become public in 2-3 years. This is the longest continuous time-series database for Antarctic ecology in existence.	US AMLR Program
Contribution to International CEOP Program	Provide ECPC results and leadership to international CEOP	International CEOP
California Coastal Salmonid Monitoring Plan Workshops	Develop a comprehensive monitoring plan for coastal salmonid populations in California	California Department of Fish and Game
Visits and Exchange Information with Asia	To broaden collaboration among countries in Asia and international bodies	China Meteorological Administration Chinese Academy of Science Indian Academy of Science UNEP USAID
Global Atmospheric Watch (GAW)	Synergy between complimentary programs	Word Meteorological Organization (WMO)
Comparative Lagoon Ecological Assessment Project	To characterize the ecology, physical, and chemical properties of Santa Cruz County, CA lagoons (estuaries)	City and County of Santa Cruz, California Department of Fish & Game, NOAA Fisheries, consultants, State & Regional Water Resources Control Board
Advice to Monterey Bay Salmon & Trout Project	Provide technical advice for the propagation of steelhead and coho salmon to promote the recovery of ESA-listed species	Monterey Bay Salmon and Trout Project
Central Valley Technical Recovery Team	Develop recommendations for recovery of ESA-listed salmonids in Central Valley	California Department of Fish & Game; NOAA Fisheries, California Department of Water Resources, University of Washington, University of California, Bay Institute
Attendance at monthly land surveyors meetings in northern (Swanson) and southern (Whitaker) California	Keep community abreast of CSRC activities	California Land Surveyors Association (CLSA)
Outreach/Academic Development		
Application Outreach	Building awareness of and support for JIMO among users	Psychology/Droought Monitoring
	To provide basic training in oceanographic procedures and to communicate the importance of long-time series of observations to members of the media, educators and the general public	Seven ship-board volunteers from diverse backgrounds, including a student from Mexico, a teacher from Long-beach, and a student from Cal State.
SEREAD Project	Integrate regional climate study and ocean data into existing curricula of South Pacific island school systems.	SOPAC, NIWA, UNESCO, SIO (D. Roemmich), POGO

CSTAR Seminar Series in Applied Theoretical Ecology	Deliver a high quality seminar series in theoretical ecology for CSTAR members and the general campus community	Speakers (affiliation): Jon Brodziak (NEFSC) , Ottar Bjornstadt (Penn State), Katriona Shea (Penn State), Jim Kitchell (Wisconsin), Simon Levin (Princeton), Robert Francis (Washington), Enric Cortes (SEFSC), Mercedes Pascaul (Michigan) Paul Dayton (Scripss), Caleb Finch (UCSC)
H. Kanamaru, J. Chen, A. Nunes, I. Meinke	Postdoctoral students	YU (Korea) faculty members
Lectures on bacteria and "red tides" in "Biological Oceanography (SIO280)" and IGERT		Summer course at UCSD/SIO
Training	Postdocs to use Regional Spectral Model for various research activities	Scripps Institution of Oceanography
Public lecture "Perspectives on Ocean Science"	Instill the importance of a historical perspective on climate to the general public.	Birch Aquarium, Scripps Institution of Oceanography
Revelle College Freshman Honors Seminar on Climate Variability	Make young students aware of opportunities/applications in environmental science.	UCSD Provost (C. Charles)
Presentations to "Nature of Science" classes	Incoming university students receive guidance about how to pursue a career in marine biology/fisheries	California State University, Monterey, CA
Database of physical, chemical and biological information available to the scientific community in the near future	Provide a historical database covering basic ecosystem parameters from one of the more remote locations of the world	Antarctic Marine Living Resources (NOAA-SWFSC).
Fishermen's Fiesta, Monterey, CA June 5, 2004	Educate the public about research activities and the biology and conservation of anadromous salmonids in Monterey Bay.	Monterey Bay National Marine Sanctuary, Monterey Maritime Museum, NOAA Weather Service, Monterey Bay Salmon and Trout
Currents Symposium, Monterey Bay State University, March 6, 2004	Educate the public about research activities and the biology and conservation of anadromous salmonids in Monterey Bay.	CSTAR Members
South Asian Workshop on Aerosol and Their Impact on Regional Climate, New Delhi, February 2-5, 2004	Capacity building and training for scientists and students in South Asia	The Energy Research Institute (TERI), New Delhi, India
Parentage Analysis Workshop	To train undergraduate students to determine animal parentage by use of microsatellite DNA analysis	UCSC undergraduate students
Course Instruction: OCN (Large Scale Air-Sea Interaction), OCN 780 (Departmental Seminar)		Univesity of Hawaii at Manoa
Otolith Preparation and Analysis Workshop	To train UC Santa Cruz undergraduate students to age and determine growth of rockfish	UCSC undergraduate students
Research Seminar	Reference Points for the Management of West Coast Groundfish	UC Davis
D. R. Cayan Participant, NOAA CCDD Science Committee, New Brunswck, NJ		

Panel Member, NOAA CCDD Proposal Rev, Washington, DC California Energy Comm PIER/DWR Water Meeting, Davis, CA Brief:Gov Schwarzenegger staffer: California Climate Research, Sacramento, CA Participant, PI Mtg For Joint Program on Climate Variability & Human Health Palnning Mtg, Hydromet Monitoring in Camp Pendleton Invited Talk, Haagen-Smit Symposium Lake Arrowhead, CA Participant, CA Modeling Seminar, Santa Barbara, CA CEC, Climate Change Meeting, Sacramento, CA LANL CEC Phil Duffy Regional Modeling Workshop, Sacramento, CA		
UCR Spatial Reference Seminar (Fall Quarter, 2003) – Bock, Whitaker, Helmer	Annual seminar to educate professionals on CSRC procedures, Web Site	Greg Helmer, CSRC volunteer, Chair CSRC Council and Executive Committee
GPS Techniques Class (Winter Quarter, 2004) -- Whitaker	Education	UC Riverside Extension
GPS Analysis Class (Spring Quarter, 2004) – Whitaker	Education	UC Riverside Extension

K-12 Outreach

Center for Informal Learning in Schools (CILS) Science Fellow Program	**UCSC Marc Mangel** is a core member of CILS, web site http://www.exploratorium.edu/cils/ and designed the CILS Science Fellows program, which allows PhD students in the natural and social sciences to learn about learning in the context of K-12 education. **Andi Stephens** is a CILS Science fellow and is in the process of developing an inquiry-based risk assessment web-tool to 3rd-8th graders **Suzanne Alonzo** taught a COSMOS course "Evolution of Animal Behavior". Nick Wolf acted as TA for this course	The Exploratorium (San Francisco), Kings College London, Mayfair Elementary School (Fresno, CA) CSTAR Members
COSMOS (CalifOrnia state Summer School for mathematics and Science)	Nick Wolf acted as a judge at a local science fair	UCSC COSMOS program
Judge at a local science fair.		Santa Cruz Unified School District
"Red Tides"	The Bishop's School, La Jolla, CA to 11th grade science students.	Presentation
California Summer School for Math & Sciences	Exposure of high school students to	Educational Partnership Center, University of

(COSMOS)	aspects of biological oceanography	California, Santa Cruz (Marinovic)
Fish anatomy	Presentation on fish anatomy & student dissections	
Web site on marine mammal sounds and JIMO project www.cetus.ucsd.edu		
Talk given to New York City Public Schools	Climate, weather and hydrological cycle	Richard Seager
Talked to principal and staff at Orange Glen HS, San Diego County (June 2, 2004) – Bock	Explained benefits of CSRC for educational purposes, upgraded SCIGN station by connecting to school's internet	San Diego County Department of Public Works

JIMO PARTNERS AND COLLABORATORS

INTERAGENCY

Alaska Fisheries Science Center
Alaska Department of Fish and Game
California Department of Fish and Game
California Department of Water Resources
California Firescope
California State University
Climate Variability and Predictability (CLIVAR)
Center for Ecology and Fire Applications (CEFA)
Cooperative Institute for Research in the Environmental Sciences (CIRES)
Desert Research Institute, University of Nevada, Reno (DRI)
International Research Institute for Climate Prediction, Columbia University (IRI)
The Inter-government Panel on Climate Change (IPCC)
Global Atmosphere Watch (GAW) Program
Government of Republic of Maldives
Joint Fire Sciences Program
National Science Foundation (NSF)
National Marine Fisheries Investigations
National Center for Environmental Prediction (NCEP)
National Ocean Partnership Program (NOPP/NSF)
National Park Service
Northwest Fisheries Science Center
Monterey Bay National Marine Sanctuary
National Weather Service, Alaska Region
Office of Naval Research (ONR)
Scripps Institution of Oceanography
Scripps Digital Image Analysis Laboratory
Southern California and Southwest Geographic Area Coordinating Center
US Global Ocean Data Assimilation Experiment (GODAE)
U.S. Dept. of Agriculture, Water Resources Conservation Service
United States Forest Service
National Aeronautical & Space Administration (NASA)
NASA SENH Program
NASA REASON CAN
CBLAST
University of California at Santa Cruz, National Marine Fisheries Service
United Nations Environment Programme
Vetlesen Foundation

PARTNERSHIPS

Beijer Institute for Ecological Economics
Busan National University, Korea

CICESE, Mexico

California Coastal Salmonid Monitoring Plan

California Energy Commission (CEC)

California Department of Water Resources

California Public Utilities Commission (PUC)

San Diego Gas and Electric.

California Independent System Operator (Cal-ISO)

California Energy Resources Scheduling (CERS)

California Department of Fish and Game, Monterey

California Bay-Delta Authority (CALFED Science Program)

California Department of Fish and Game

Caltrans Office of Land Surveys, Division of Right of Way and Land Surveys

DSI Power

International Centre for Mountain Development, Katmandu, Nepal

International RSM Community

International Pacific Research Center, School of Ocean and Earth Science and Technology
Division of Earth & Planetary Sciences, Hokkaido University, Japan

John Muir Institute of the Environment (UCD)

MRAG Americas, Tampa, FL

Ministry of Population and Environment, the Royal Government of Nepal

Ministry of Home Affairs and Environment, Republic of Maldives

Monterey Bay Salmon and Trout Project

Moss Landing Marine Laboratory

Orange County Public Facilities and Resources Division

Pacific Marine Environmental Laboratory (NOAA)

Atlantic Oceanographic and Meteorological Laboratory (NOAA)

National Marine Fisheries Service (NMFS)

NOAA-AMLR

Climate Services Division and its Climate Predication Center in Washington, D.C. (NWS)

Pacific Gas and Electric

Riverside County Flood Control and Water Conservation District

PacifiCorp

San Diego County Sheriffs' Department

San Diego County Department of Public Works

Sempra Utilities

SoCal Gas

Sierra Energy

Southern California Coastal Ocean Observing System (SCCOOS)

Southern California Metropolitan Water District

US Fish and Wildlife Service

UNEP Resource Centre for Asia-Pacific Office, Bangkok, Thailand

University of Chulagongkorn, Bangkok, Thailand

University of Washington

COLLABORATORS

Woods Hole Oceanographic Institution (WHOI)
Andres Aguilar, University of Santa Cruz, Dept. of Ocean Sciences
Mike Alexander, NOAA /CIRES
Jim Anderson, University of Washington
Björn G. Andersen, University of Oslo
Valerie Andreassi, NOAA Fisheries, Southwest Fisheries Science Center
Art Andrew, Orange County Public Facilities and Resources Division
David Barrell, Institute of Geological and Nuclear Sciences, New Zealand
M. Beck, The Nature Conservancy, Santa Cruz, CA
James Bellingham, Monterey Bay Aquarium Research Institute
Steve Bograd, NOAA /PFE
M. Bonsall, Imperial College, London
T. Brown, Center for Ecology and Fire Applications (CEFA)
Tim Brown, Desert Resea Institute, University of Nevada, Reno)
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Center for Integrated Marine Technology (CIMT)
Shyh Chen, USFS
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John Colosi, Woods Hole Oceanographic Institution
D. Conover, SUNY Stonybrook
A. Cooper, University of New Hampshire
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Paul Crone, Southwest Fisheries Service Center
Chris Daly, Oregon State University
Clara Deser, National Center for Atmospheric Research
Ann Dieffenbacher-Krall, University of Maine
Dr. David Ebert, Moss Landing Marine Laboratory
Environment Division, World Meteorological Organization, Geneva, Switzerland
Francis Fujioka, USFS
Desert Research Institute, University of Nevada, Reno
Walt Duffy, Humboldt State University
The Energy Research Institute, New Delhi, India
David Fratantoni, Woods Hole Oceanographic Institution
Francis Fujioka, USFS
Georgia Institute of Technology
Frank Gehrke, California Department of Water Resources
Luisa Grieco, Institute of Meteorology and Oceanography, Parthenape University Via De Gasperi, Naples Italy
Seth Gutman, NOAA FSL
B. Hall, Program for Climate, Ecosystem and Fire Applications (CEFA)
David Hankin, Humboldt State University
Scott Harris, California Department of Fish and Game
Kate Hedstrom University of Alaska, Fairbanks

Gary Hufford, U.S. National Weather Service, Alaska Region

Anitra Ingalls (University of Washington)

Hydrologic Research Center – Del Mar, CA
K. Georgakakos, N. Graham, S. Taylor

Stan Jacobs, Lamont-Doherty Earth Observatory, Columbia University

Jet Propulsion Laboratory, Pasadena
Frank Webb, Sharon Kedar, Danan Dong, Brian Newport

Chet Koblinsky, NOAA Climate Office

Institute for Global Change Research, Yokohama, Japan

International RSM Community

Investigaciones Mexicanas de la Corriente de California (IMECOCAL)

José Luis Iriarte, Universidad Austral de Chile

Dr. Milton Love, UCSB

Max Planck Institute for Chemistry, Mainz, Germany

Bernie May, University of California, Davis

Roy Mendelssohn, NOAA/PFEL

S. Minobe, Division of Earth & Planetary Sciences, Hokkaido University, Japan

Dave L. Musgrave, University of Alaska, Fairbanks

National Physical Laboratory, New Delhi, India

National University, Seoul, Korea

NASA - Goddard Space Flight Center, Maryland, USA

C. Needle, MAF, Aberdeen, Scotland

Mike Neubert, Woods Hole Oceanographic Institution

Ken Newman, University of St. Andrews, Scotland.

Jon Olafsson, University of Iceland and the Iceland Marine Research Institute

Peking University, Beijing, China

K. Redmond, Western Regional Climate Center (DRI)

Julian Sachs (Massachusetts Institute of Technology)

James Sanchirico, Resources for the Future

Christian Schlüchter, University of Bern

Frank Schwing, NMFS

Rene Servranckx, Canadian Meteorological Center

K. Shea, Pennsylvania State University

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Andy Solow, Woods Hole Oceanographic Institution

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P. Switzer, Eastern Illinois University

William Sydeman, Point Reyes Bird Observatory

United States Geological Survey
San Diego D. Cayan, M. Dettinger
Menlo Park D. Peterson, N. Knowles, I. Stewart

Climate Modeling and Dynamics Laboratory, Boulder, Colorado, USA (NOAA)

University of Iowa, Iowa City, Iowa, USA

University of Miami, Miami, Florida, USA

University of Stockholm, Stockholm, Sweden

University of Tokyo, Tokyo, Japan

University of Wisconsin, Madison, Wisconsin, USA

UNAVCO, Boulder, Colorado
Mike Jackson, Chris Walls, Plate Boundary Observatory

Marcus Vandergoes, University of Maine

Watershed Restoration Program for Santa Cruz County

G. Watters, NMFS/PFEL

Lisa Wooninck, NMFS

Meng Zhao, University of Massachusetts, Boston

REPRESENTING JIMO

CONFERENCE NAME	DATE (month, year)	PERSONNEL
Oceans 2003 Conference	September 2003, San Diego, CA	Peter D. Bromirski, Arthur J. Miller and Reinhard Flick
California Climate Change Conference	June 2004, Sacramento, CA	
CalCOFI Annual Conference	November 5-7, 2003, Asilomar Conference Center, Pacific Grove, CA	Elizabeth L. Venrick
84th AMS Annual Meeting	January 2004, Seattle, WA	E. Yulaeva and N. Schneider
1st International CLIVAR Conference	June 21-26, 2003, Baltimore, Maryland	N. Schneider and S. Minobe
American Geophysical Union	December 2003, San Francisco, CA	E. Yulaeva and N. Schneider
International Association of Impact Assessor's Annual Meeting	May 26-30, 2004, Vancouver, BC, Canada	
American Fisheries Society Larval Fish Conference	August 20-23, 2003, Santa Cruz, CA	CSTAR Members
International Workshop on Bayesian Data Analysis	August 8-10, 2003, Santa Cruz, CA	CSTAR Members
6th Biennial State of the Estuary Conference	October 21-23, 2003, Oakland, CA	CSTAR Members
Environmental Water Account Review III/Water Operations Science Symposium II	October 15-17, 2003. Sacramento, CA	CSTAR Members
Central Valley Salmonid Recovery Planning Workshop	September 8-9, 2003 UC. Davis, Davis, CA	CSTAR Members
Environmental Water Account Delta Smelt Third Annual Workshop	August 18, 2003. NOAA Fisheries, Santa Cruz, CA	CSTAR Members
Environmental Water Account Salmonid Third Annual Workshop	July 15-16, 2003. Sacramento State University, Sacramento, CA	CSTAR Members
CALFED Science Symposium I: Environmental and Ecological Effects of Proposed Changes in Water Operations	June 19-20,2003. Sacramento, CA	CSTAR Members
2003 CALFED Science Conference	January 14-16, 2003, Sacramento, CA	CSTAR Members
Marine Reserves Consensus Conference: Integrating Science and Fisheries Management	National Fisheries Conservation Center's	
Ecological Society of America	March 2004, Bodega Bay, CA	CSTAR Members
Bay Area Institute	August 15-19, 2003, Santa Cruz, CA	CSTAR Members
California Estuarine Research Society	March 2004, Bodega Marine Laboratory, Bodega Bay, CA	CSTAR Members
Recreational CPUE Statistics Workshop	June 2004, Santa Cruz, CA	CSTAR Members

California Estuarine Research Society Annual Meeting	March 2004, Bodega Marine Laboratory, Bodega Bay, CA	CSTAR Members
International Conference on Pale-oceaongraphy	Sept 6-10, 2004, Biarritz FR	Sydney Hemming
UC Santa Cruz, Department of Environmental Studies	November 2003, Santa Barbara, CA	S.B. Munch
Alaska Fisheries Science Center	February 2004, Newport, OR	S.B. Munch
The Ocean Conservancy	May 2004	S.B. Munch
88th Ecological Society of America Annual Meeting	August 2003, Savannah, GA	M.L. Snover and G.M. Watters
Hopkins Marine Laboratory	November 2003, Pacific Grove, CA	M. L. Snover
Workshop in Individual-Based Modeling	May 27, 2004, University of Bergen, Bergen, Norway	N. Wolf
Recreational CPUE Statistics Workshop	June 2004, Santa Cruz, CA	A. Stephens
The 8th NMFS National Stock Assessment Workshop	March 2004, Newport, RI	A. Stephens
5th International RSM Workshop	July 13-17, 2004 Seoul, Korea	J. Roads
Climate Reference Network Workshop	March 25-26, 2003, NOAA National Climate Data Center (NCDC), Anchorage, AL	Invited speaker. Alaskan Surface Temperature and Precipitation
NOAA Climate Service's Division Alaska Workshop	July 10-12, 2003, Fairbanks, AL	Invited Speaker
CLIVAR Science Conference	2004, Baltimore, MD	
International Liège Colloquium on Ocean Dynamics	May 2004, Liege, France	
1st EGS-AGU-EUG General Assembly	April 2004, Nice, France	
ECCO Meeting	June 2003, San Diego, CA	
Population Genetics in Animal Conservation	September 3-5, 2003, Trento, Italy	
Application of Stock Identification in Defining Marine Distribution and Migration of Salmon	November 1-2, 2003, Honolulu, HI	
Coastwide Salmon Genetics Meeting	June 16-18, 2004, Newport, OR	
National Seasonal Assessment Workshop	January 27-29, 2004, Shepersdtown, West Virginia	
Mosquito Vector Control Association of California Annual Meeting	February 1-3, 2004, Sacramento, CA	
PACLIM: Pacific Climate Workshop	March 28-31, 2004, Pacific Grove, CA	
Mountain Climate Sciences Symposium	May 25-27, 2004, Lake Tahoe, California	
Population Genetics in Animal Conservation	September 3-5, 2003, Trento, Italy	
Application of Stock Identification in Defining Marine Distribution and Migration of Salmon	November 1-2, 2003 Honolulu, HI	

2nd Annual CEOP Meeting	March 2004, UCI, Irvine, CA	
Spring AGU/CGU Meeting	May 2004, Montreal, Canada	
85th Annual AMS Meeting	January 2005, San Diego, CA	
3rd Annual CEOP Meeting	March 2005, Tokyo, Japan	
Fall AGU Meeting	December 2003, San Francisco, CA	
California Coastal Salmonid Monitoring Plan Workshop I	March 9-11, 2004, Santa Cruz, CA	
California Coastal Salmonid Monitoring Plan Workshop II	May 24-26, 2004, Sacramento, CA	
ARGO Workshop	November 2003, Tokyo, Japan	Luca Centurioni
DBCP-19	October 2003, Rio de Janerio, Brazil	Peter Niiler, Luca Centurioni and William Scuba
NASA/Scatterometer Workshop	September 2003, Pasadena, CA	Peter Niiler
NOAA Workshop on "Ocean Climate Observations"	June 2003 and April 2004, Silver Spring, MD	Peter Niiler
EGS Meeting	April 2004, Nice, France	Luca Centurioni
South Asian Workshop on Aerosol and Their Impact on Regional Climate	February 2-5, 2004, New Delhi, India	Various Members of ABC
Dubai International Conference on Air Pollution	February 2004, Dubai, United Arab Emirates	Various Members of ABC
Fall Meeting of the American Geophysical Union	December 8-12, 2003, San Francisco, CA	Various Members of ABC
Spring Meeting of the American Geophysical Union	May 17-21, 2004, Montreal, Canada	Various Members of ABC
Seminar at Caltech	September 9, 2003, Pasadena, CA.	
Workshop on Detection and Localization of Marine Mammals Using Passive Acoustics	November19-21, 2003, Dartmouth, Nova Scotia, Canada	John Hildebrand and Sean Wiggins
International GPS Service 10th Anniversary Workshop	March 1-5, 2004, Bern, Switzerland	Yehuda Bock
Presentations/Seminars Symposiums		
US Rep. Ken Calvert	August 22, 2003, San Diego, CA	Dan Cayan
CA Assembly Committee Environment Safety & Toxic Materials	August 25, 2003, Sacramento, CA	Dan Cayan
CA Assembly Member George Plescia 75th District visit	September 30, 2003, UC	Dan Cayan
SIO Meets CA Resources Data Managers Meeting	October 22, 2003 Sacramento, CA	Dan Cayan
Invited Talk to Members of Congress	October 24, 2003, Birch Aquarium, San Diego, CA	Dan Cayan
Participant, California Energy Commission PIER-EA's Global Technical Committee	October 28, 2003 - Sacramento, CA	Dan Cayan
Brian Baird (CA Resources Agency Ocean Program Manager), Mary Glackin (Assistant Administrator for Program Planning and Integration,	June 3, 2004, Scripps Institution of Oceanography	D. Cayan

NOAA) and Pete Silva (Vice Chair, CA State Water Resources Quality Control Board).. Included in the events of the day was a tour of the SIO Visualization Center.		
California Emergency Water Account Workshop	July 15, 2003, Sacramento, CA	Dan Cayan
2003 Larval Fish Conference	August 20-22, 2003, Santa Cruz, CA	Dan Cayan
Central Valley Technical Recovery Team Conference	September 8-9, 2003, Davis, CA	Dan Cayan
Santa Cruz County Conservation District presentation	September 24, 2003, Santa Cruz, CA	Dan Cayan
Presentation to Recovery Science Review Panel	September 15-17, 2003, Santa Cruz, CA	Dan Cayan
Santa Lucia Gradient Study Workshop,	February 6, 2004, Santa Cruz, CA	Dan Cayan
Monterey Bay National Marine Sanctuary Symposium	March 6, 2004, Seaside, CA	Dan Cayan
California Estuarine Research Society 2004 Annual Meeting	March 23-24, 2004. Bodega Marine Laboratory, Bodega Bay, CA.	CSTAR Members
American Fisheries Society	February 2004. Oregon Chapter, Sun River, OR April 2004, CA-NV Chapter, Redding, CA February 2004, Western Division, Salt Lake City, UT	Pete Adams, UCSC
Coastwide Salmonid Genetics Meeting	June 2004, Newport, OR	Pete Adams, UCSC
ESRI International Users Conference	July 2003, San Diego, CA	Pete Adams, UCSC
EWA Salmon Workshop	July 2003, Sacramento, CA	
Lower Klamath River Basin Science Conference	June 2004, Arcata, CA	Pete Adams, UCSC
NOAA Fisheries Recovery Science Review Panel	December 2003, Santa Cruz, CA.	Pete Adams, UCSC
Redwood Region Forest Science Symposium	March 2004, Santa Rosa, CA	CSTAR Members
27th Larval Fish Conference	August 2003, Santa Cruz, CA	CSTAR Members
International Workshop on Bayesian Data Analysis	August 2003, Santa Cruz, CA	CSTAR Members
Symposium of the Conference, California Cooperative Oceanic Fisheries Investigations Annual Conference	November 2003	CSTAR Members
Systems Engineering Seminar	November 2003, Naval Postgraduate School, Monterey, CA	CSTAR Members
Seminars on Ecology and Evolution	March 2004, University of Amsterdam, The Netherlands	CSTAR Members
Zoological Society of London Symposium on 'Management of	April 2004, London, UK	CSTAR Members

Marine Ecosystems: Monitoring Change in Upper Trophic Levels'		
Redwood Region Forest Science Symposium	March 2004, Santa Rosa, CA	CSTAR Members
North Pacific Anadromous Fish Commission	2003	
American Meteorological Society, 83rd Annual Meeting, Impacts of Water Availability Symposium	February 2003 Long Beach	Dan Cayan, M.D. Dettinger, I. Stewart and N. Knowles
Annual Meeting, Council for State Governments	July 2003, West, Honolulu, CA	M. D. Dettinger
USGS Western Region Science Seminar	September 2003	M. D. Dettinger
Southwest Drought Summit	2003	M. D. Dettinger and G. McCage
28th NOAA Climate Diagnostics and Prediction Workshop	October 2003, Reno, NV	M. D. Dettinger, K.T. Redmond and D.R. Cayan
California Energy Commission's First Annual Climate Change Conference: From Climate to Economics, Anticipating Impacts of Climate Change in California	June 9-10, 2004, Sacramento, CA	K. P. Georgakakos, N.E. Graham and A.P. Georgakakos
AMS 5th Conference on Coastal Atmospheric and Oceanic Prediction and Processes	August 6-8, 2003, Seattle, WA	N. E. Graham and S.V. Taylor
American Water Resources Association Annual Conference	2003, San Diego, CA	R. T. Hanson. M.D. Dettinger, M. Newhouse and J.E. Dickinson
American Geophysical Union	December 2003	J. D. Lundquist and M. D. Dettinger
International Conference on Hydrology of Mountain Environments	2004	J. D. Lundquist, D. Cayan and M. Dettinger
AMS 5th Conference on Coastal Atmospheric and Oceanic Prediction and Processes	August 6-8, 2003, Seattle, Washington	S. V. Taylor and N.E. Graham
21st Annual Pacific Climate Workshop	March 28-31, 2004 Asilomar, CA	S. V. Taylor, S.V., Graham, D. R. Cayan and K. P. Georgakakos
17th Biennial Conference of the Estuarine Research Federation	2003, Seattle, WA.	J. K. Thompson, F. Parchaso, D. Cayan, M. M. Dettinger, N. Knowles, and D. Peterson
Oceans 2003 Conference	September 2003, San Diego, CA	P. Bromirski and A. Miller
California Climate Change Conference	June 2004, Sacramento, CA	P. Bromirski and A. Miller
Executive Meeting of Intergovernmental Oceanographic Commission, UNESCO	Introduce ARGO to a wider group of countries than are presently involved.	D. Roemmich
AMS 5th Conference on Coastal	August 6-8, 2003, Seattle, WA	N. E. Graham and S.V.

Atmospheric and Oceanic Prediction and Processes		Taylor
American Water Resources Association Annual Conference	2003, San Diego, CA	R. T. Hanson. M.D. Dettinger, M. Newhouse and J.E. Dickinson
American Geophysical Union	December 2003	J. D. Lundquist and M. D. Dettinger
International Conference on Hydrology of Mountain Environments	2004	J. D. Lundquist, D. Cayan and M. Dettinger
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17th Biennial Conference of the Estuarine Research Federation	2003, Seattle, WA.	J. K. Thompson, F. Parchaso, D. Cayan, M. M. Dettinger, N. Knowles, and D. Peterson
Oceans 2003 Conference	September 2003, San Diego, CA	P. Bromirski and A. Miller
California Climate Change Conference	June 2004, Sacramento, CA	P. Bromirski and A. Miller
Executive Meeting of Intergovernmental Oceanographic Commission, UNESCO (W.J.Gould)	Introduce ARGO to a wider group of countries than are presently involved.	D. Roemmich
AMS 5th Conference on Coastal Atmospheric and Oceanic Prediction and Processes	August 6-8, 2003, Seattle, WA	N. E. Graham and S.V. Taylor
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American Geophysical Union	December 2003	J. D. Lundquist and M. D. Dettinger
International Conference on Hydrology of Mountain Environments	2004	J. D. Lundquist, D. Cayan and M. Dettinger
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21st Annual Pacific Climate Workshop	March 28-31, 2004 Asilomar, CA	S. V. Taylor, S.V., Graham, D. R. Cayan and K. P. Georgakakos
17th Biennial Conference of the Estuarine Research Federation	2003, Seattle, WA.	J. K. Thompson, F. Parchaso, D. Cayan, M. M. Dettinger, N. Knowles, and D. Peterson
Oceans 2003 Conference	September 2003, San Diego, CA	P. Bromirski and A. Miller
Partnership for Observing the Global Ocean (POGO)	Highlighting to ocean research institutions the progress made and	D. Roemmich

(W J Gould)	opportunities presented by Argo	
Union of Concerned Scientist, Climate Change & California Central Valley	January 1, 2004, Berkeley, CA	D. Cayan
IRCCI/SNRI Workshop	July 27-29, 2003, Yosemite National Park, CA	D. Cayan
NOAA Research Visit, Presentation, Mary Glackin	June 3, 2004, UCSD/SIO	D. Cayan
City of San Diego, Ad Hoc Environmental Committee Meeting	August 14, 2003, San Diego, CA	D. Cayan
After Dinner Talk, "Changes in Snowmelt" Hydro Res Cntr Anniv Celebration	September 6, 2003, La Jolla, CA	D. Cayan
HPWREN Users Meeting	September 11, 2003, Palomar Observatory, CA	D. Cayan
NOAA / NWS Climate Predication Center	January 27, 2004, Washington, D.C.	J. J. Simpson
Anchorage, Alaska Surface Temperature and Precipitation. NOAA Climate Service's Division Alaska Workshop	July 10-12, 2003, Fairbanks, AK	J. J. Simpson
Long-term Climate Patterns in Alaska Surface Temperature and Precipitation	January 22, 2004, NWS Climate Service Division, Washington, D.C.	J. J. Simpson
Wakefield Symposium	October 2003, Alaska	James E. Wilen
Workshop on Spatial/Dynamic Modeling,	April 2004, Trieste Italy	James E. Wilen
Partnership for Observing the Global Ocean (POGO) (W J Gould)	Highlighting to ocean research institutions the progress made and opportunities presented by Argo	D. Roemmich
Union of Concerned Scientist, Climate Change & California Central Valley	January 1, 2004, Berkeley, CA	D. Cayan
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NOAA Research Visit, Presentation, Mary Glackin	June 3, 2004, UCSD/SIO	D. Cayan
City of San Diego, Ad Hoc Environmental Committee Meeting	August 14, 2003, San Diego, CA	D. Cayan
After Dinner Talk, "Changes in Snowmelt" Hydrographic Research Center Anniversary Celebration	September 6, 2003, La Jolla, CA	D. Cayan
HPWREN Users Meeting	September 11, 2003, Palomar Observatory, CA	D. Cayan
NOAA / NWS Climate Predication Center	January 27, 2004, Washington, D.C.	J. J. Simpson
Anchorage, Alaska Surface Temperature and Precipitation. NOAA Climate Service's Division Alaska Workshop	July 10-12, 2003, Fairbanks, AK	J. J. Simpson

Long-term Climate Patterns in Alaska Surface Temperature and Precipitation	January 22, 2004, NWS Climate Service Division, Washington, D.C.	J. J. Simpson
Wakefield Symposium,;	Oct 2003, Alaska	James E. Wilen
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NOAPA82.UCSC.ADAMS PRESENTATION LISTING		
Partnership for Observing the Global Ocean (POGO) (W J Gould)	Highlighting to ocean research institutions the progress made and opportunities presented by Argo	D. Roemmich
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IRCCI/SNRI Workshop	July 27-29, 2003, Yosemite National Park, CA	D. Cayan
NOAA Research Visit, Presentation, Mary Glackin	June 3, 2004, UCSD/SIO	D. Cayan
City of San Diego, Ad Hoc Environmental Committee Meeting	August 14, 2003, San Diego, CA	D. Cayan
IMAGES Holocene Working Group,	August 2003, Norway	Richard Seager
PAGES/CLIVAR/IMAGES Millennial Perspective on Drought Workshop	November 2003, Tuscon, AZ	Richard Seager and M. Cane.
14th Conference on Atmospheric and Oceanic Fluid Dynamics	San Antonio, TX	Nilii Harnik
Role of Stratosphere in Tropospheric Climate Workshop	May-June 2003, Whistler, BC	
EURESCO Conference on Using Paleoclimate Data to Achieve Climate Prediction	October 2003, Spain	Yochanan Kushnir
CLIVAR Atlantic Predictability Workshop, Reading, UK		
11th International Symposium on Deformation Measurements	May 25 - 28, 2003, Santorini, Greece	M. Duffy and C. Whitaker
Harmful Algal Blooms" talk to SeaDeucers dive club		P. Franks, UCSD/SIO
"Red Tides"		Institute for Continued Learning, UCSD
Annual Climate Assessment for Interagency Fire danger	Provide summaries of ECPC fire danger forecasts to interagency Fire danger forecasters	USFS, National Interagency Coordinating Committee
Energy Modeling forum—climate change impacts	Assessment of risks of future climate change	DOE, Stanford University
Marine Biology Seminar		Scripps Institute of Oceanography (Garza
Life Sciences Seminar		Santa Clara University-(Garza)
Environmental Sciences Seminar		UC Berkeley, (Garza)
American Fisheries Society Annual		(Garza)

Meeting		
California Population and Evolutionary Geneticists Meeting		(Clemento)
Seminar at Goddard Space Flight Center (NASA) “Free Tropospheric Quasi-equilibrium and its Impact on Climate Simulation”	Communicate Research Results to Scientific Community	G. Zhang
Seminar on height modernization, Arizona State Land Surveyors Conference (Whitaker and Helmer), March 2004	Per request by National Geodetic Survey to support national height modernization program	Greg Helmer, CSRC volunteer, Chair CSRC Council and Executive Committee
Annual meeting of League of California Surveying Organizations, Southern Region (Helmer), Riverside, April 1, 2004.	This is an important venue for highlighting CSRC accomplishments and receiving public feedback, and relating our efforts to those of NGS, PB,O, SCIGN	Riverside County Flood Control and Water Conservation District hosted the meeting.
Seminar by invitation at two branches of a government research facility	Bologna and Rome, Italy	Yehuda Bock
Harmful Algal Blooms” talk to SeaDeucers dive club		P. Franks, UCSD/SIO

PUBLICATIONS

PUBLISHED PAPERS

Anderson, B. T., and J. O. Roads. Regional simulations of summertime precipitation over the southwestern United States. **J. Climate** 15. 3321-3342. (2002).

Cuny, J., P.B. Rhines, P.P. Niiler, and S. Bacon. Labrador Sea boundary currents and the fate of the Irminger sea water. **J. Amer. Meteorol. Soc.** 32. 627-647. (2002).

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Anderson, C.J., R. W. Arritt, E. S. Takle, Z. T. Pan, W. J. Gutowski, F. O. Otieno, R. da Silva, D. Caya, J. H. Christensen, D. Luthi. Hydrological processes in regional climate simulations of the central United States flood of June-July 1993. ***J. Hydrometeor.*** 4. 584-598. (2003).

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Auad, G., J. P. Kennett, and A. J. Miller. North Pacific intermediate water response to a modern climate shift. **J. Geophys. Res.** 108. (C11): Art. No. 3349. (2003).

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Bromirski, P.D., R.E. Flick, and D.R. Cayan. Storminess variability along the California Coast: 1858-2000. **J. Climate** 16. (6): 1-12. (2003).

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PUBLICATION SUMMARY

	JIMO LEAD AUTHOR			NOAA LEAD AUTHOR			OTHER		
	FY02	FY03	FY04	FY02	FY03	FY04	FY02	FY03	FY04
PEER-REVIEWED	23	24	76	2	4	20	30	32	30
NON PEER-REVIEWED	56	40	52	0	0	12	61	41	28
	79	64	128	2	4	32	91	73	58